Materials & Methods

Selection & use of
metals, nonmetallics, parts, finishes,
in product design & manufacture

UNIV
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APR 16 1957

April, 1957

Electrical Insulation Materials—M & M Manual

Combination Laminates

Creep Properties from Short Time Tests

Carburized Iron Power Parts

Epoxy Coatings for Metal Products

Dry Bearing Materials

Self-Expanding Thermoplastic Foam

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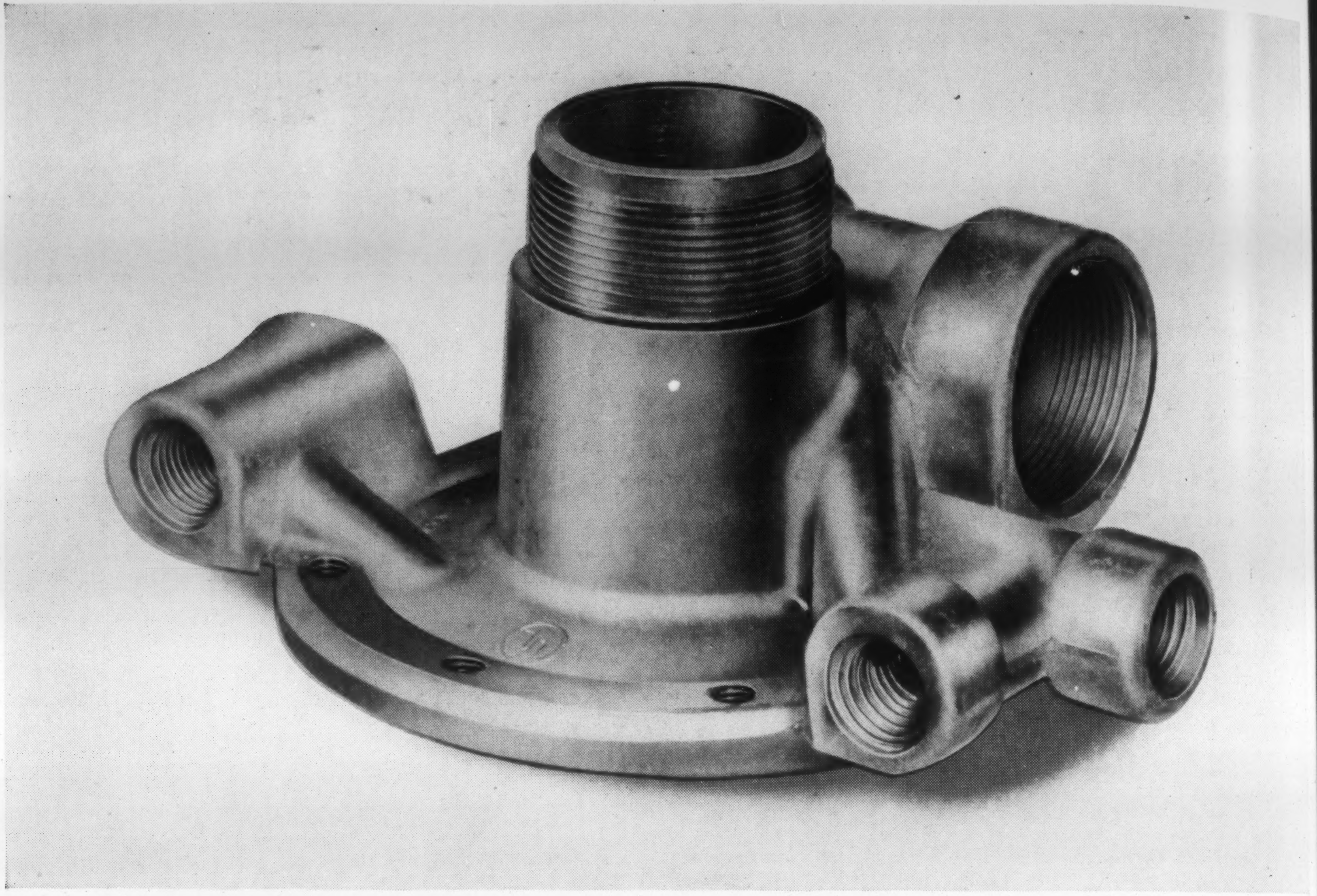
Complete Contents—page 1



Anaconda Die Pressed Brass Forging after machining, ready for assembly in the gas-pressure regulator shown below.

Better regulators at less cost—with die pressed forgings

Save 25% in first cost—cut machining time, tool cost

Smith Welding Equipment Corp. of Minneapolis uses Anaconda Die Pressed Brass Forgings for gas-pressure regulator bodies as a result of the following analysis of the job.

First, die pressed forgings make a superior product because the twice-wrought metal has the uniformity, denseness, toughness, and strength to prevent gas leaks and to withstand pressures that run in excess of 2500 psi. And second, the forgings do the job economically. The initial cost of the die pressed forging is 25 percent less than the cost of sand castings. In addition, savings are realized in substantially reduced tool costs and machining time. And finally, the forgings are finished in a simple bright-dipping operation, with savings over sand castings estimated at 5 cents a unit.

SHORT CUTS: Anaconda Die Pressed Forgings are short cuts to superior products. Because of their high strength, hardness and resistance to impact, abrasion, and corrosion, they serve better functionally, often replacing more costly built-up assemblies of cast, stamped, drawn, or other machined parts. Their consistent accuracy of dimension eliminates most surface machining to size, permits trouble-free use of drilling jigs, threading or milling fixtures, broaching vises in secondary operations. They are ideally suited to high-speed automatic chucking machines.

The die pressed forging technique is practically unlimited in diversity of shape and field of application. Specialists at The American Brass Company will be glad to submit estimates on the cost of forgings for your critical components. Just submit a sketch or sample of the part involved—or write for Publication B-9. Address: The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Limited, New Toronto, Ontario.

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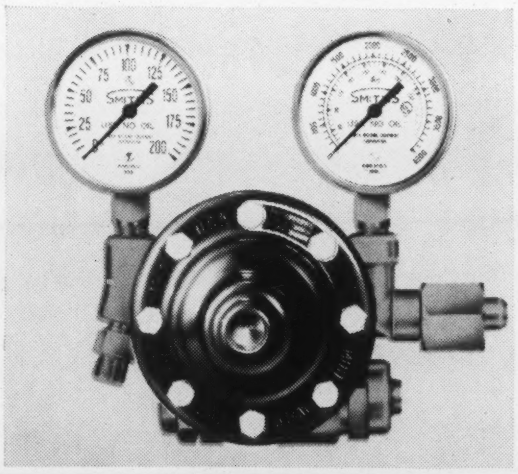

Smith's two-stage oxygen regulator, Model H313. One of the Smith Welding Equipment Corp. products using Anaconda Die Pressed Brass Forgings.

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Short cuts to superior products

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Materials & Methods®

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Materials & Methods is indexed regularly in the Engineering Index and the Industrial Arts Index

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Three-quarters of it is sodium chloride — common salt. The other quarter consists of a natural mixture containing so-called "trace elements" — tiny amounts of copper and cobalt and magnesium . . . zinc . . . molybdenum . . . manganese . . . calcium . . . and other elements and minerals.

Experts believe that these trace elements may hold the key to many health problems. And with reason. Hasn't iodine been used to prevent goiter? Fluorine to stop tooth decay? Iron to overcome anemia?

Hence a spanking new plant—35 miles south of Corpus Christi, Texas — to produce *Admiral* Sea Salt from Baffin Bay, where the water is almost twice as salty as average sea water. Of course, the high salt content is an advantage from a manufacturing standpoint. But from the angle of plant designing — !

Engineers faced two potentially serious corrosion problems. Attack on *inside* surfaces of equipment by this extra-salty water . . . and attack on *outside* surfaces by salt-laden breezes.

Use of Monel* nickel-copper alloy in the more critical pieces of plant equipment avoids both hazards. Monel alloy is one of a family of Inco Nickel Alloys noted for corrosion resistance. Widely used in chemical, petroleum, marine and other industries where acids or alkalies are frequent troublemakers, Monel provides a ready solution to many common problems.

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What's new IN MATERIAL

...AT A GLANCE

A NEW CORROSION PREVENTIVE LINING MATERIAL, an elastomeric copolymer based on vinylidene chloride, is now available. The flexible thermoplastic material resists a broad range of acids, alkalies, salt solutions and solvents. It can be readily installed with an adhesive.

COLUMBIUM offers promise as a high temperature material. Compared with molybdenum, the material has better oxidation resistance and retains its ductility after heating to elevated temperatures. Although columbium readily reacts with oxygen, nitrogen and hydrogen, it is easier to fabricate than other high melting metals. (See article in next month's issue for further details.)

SYNTHETIC FIBERS are being evaluated as reinforcing agents for acrylic resins and polyethylene. Impact strength of an acrylic resin is said to be improved eight times by reinforcing it with Orlon fibers. Although synthetic fiber reinforcement of polyethylene is still in the initial stage, it has been found that important gains in physical properties can be achieved with relatively minor fiber additions.

A NEW HIGH STRENGTH, HIGH TEMPERATURE ALLOY is finding use as turbine disks in jet engines. The material is essentially an alloy of iron, nickel, chromium, molybdenum, titanium and boron. It withstands 75,000 psi stress at 1200 F for 300 hr; under the same conditions a conventional turbine disk lasts only 10 hr. (More details next month.)

ISOTACTIC POLYPROPYLENE, twice as strong as ordinary polyethylene, is being made on a pilot plant scale in Italy. Like polyethylene, the material is expected to be useful in the form of film, moldings, pipe, bottles, and wire and cable insulation. Another potential use: a synthetic fiber for filter cloths and upholstery.

NEW GLASS DISPERSIONS provide a protective and lubricating coating during the forging of special alloy steels, titanium and other metals. Applied to metals at room temperature, the glass fuses to the surface of the metal during the heating cycle and inhibits oxidation and surface contamination.

STRONGER SHEET MATERIALS are possible with a new German technique that shapes metals, plastics, pressed wood and glass into sheets having raised surfaces. It is claimed that the new technique increases ductility making the material 80 to 100% more impact resistant than ordinary sheet materials. Two or more sheets can be joined into a single panel having buckling and bending strengths more than ten times that of similar flat sheet structures.

QUICK IDENTIFICATION OF NONFERROUS METALS is possible with an electronic device. Small enough to be carried in the hand, the instrument contains a calibrated dial that measures electrical resistivity of the material. Metals and alloys can be distinguished provided their specific resistivities are between 1 and 28 microhms per cu cm.

PLASTICS PIANO MECHANISMS are now being made in France. Unlike wood, the plastics mechanisms do not contract or expand under different climatic conditions and are resistant to chemicals and heat. Made of an unidentified plastic, the mechanisms are molded and do not require expensive machining operations.

ALUMINUM AND PLASTICS will be commonplace in the home of tomorrow, according to recent reports. Radiant heating aluminum rugs and wallpaper, as well as plastics plumbing fixtures and molded plastics bathrooms will be found in the future home. Plastics domes covering both house and garden are also projected.

HIGH DENSITY POLYETHYLENE, a new material two years ago, is finding increasing use in toys, hot water pipes, fibers and woven fabrics. Currently, six chemical companies are building facilities for producing this resin. The material, said to be more oil and acid resistant than low density polyethylene, is also finding use in refrigerator trays that won't bend easily, and in containers that can be washed in automatic dishwashers without melting.

AN ELECTRONIC DEVICE utilizing a magnetic ferrite core is being used instead of transistors in Japan. The device, consisting of a coil, magnetic core and condenser, is cheaper to manufacture and has fewer electrical contacts than a transistor.

A NEW CLASS OF TITANIUM ALLOYS is claimed to react to heat treatments "very much like steel." Not yet in commercial use, the new alloys contain titanium, copper, aluminum and tin. They are strong and ductile at temperatures up to 1000 F.

A CERAMIC FOAM MATERIAL is capable of withstanding temperatures up to 1600 F. Compressive strength of the material is above 400 psi at both room temperature and 1600 F. It is recommended as an insulating material for aircraft parts and as a core material for electronic parts. (More details next month.)

ALUMINUM POWDER is being rolled into strip. Additional rolling causes the formation of a reasonably ductile foil by cold welding.

Turn to page 171 for more "What's New in Materials"

MATERIALS BRIEFS

Not Very Attractive
Results of measuring the magnetism of bricks made in 1933, 1465 and 200 A.D. show that today's magnetic field is some 18% weaker than in 1465 and 35% weaker than in the year 200.

Fish Story
Tropical fish are being transported in sealed plastics bags of water in which the air is displaced by pure oxygen. The fish can remain in the bag for several days without harm.

Blades for Bamboo
Japanese craftsmen use 400-year-old samurai swords as knives for carving bamboo. They say that steel forged after 1596 is inferior for cutting the extremely hard wood.

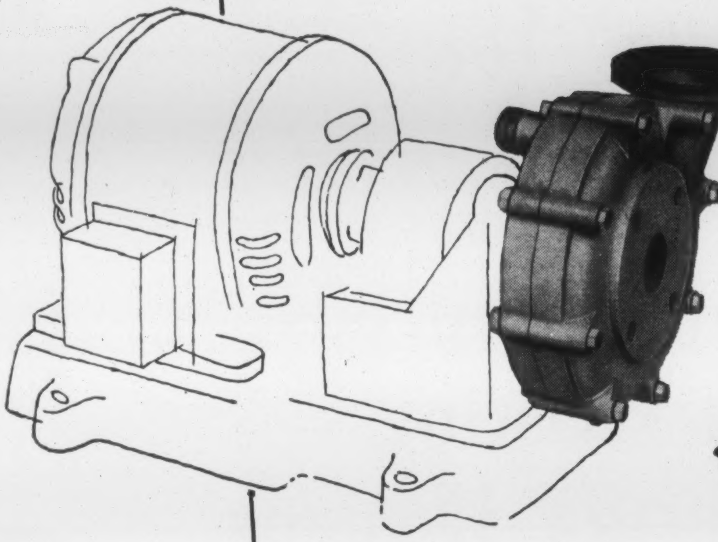
Look! No Holes
An epoxy coating 0.001 in. thick may be used on teeth someday to prevent cavities. The coating would be applied by a dentist every six months.

'Drag' for Junior
A rear-engine sports car made of reinforced plastics is the latest thing in toys. Complete with lights and dual exhausts, the car will do a cool 30 mph.

Cool Audience
The Navy has developed a dummy that listens. Used to test ear protection devices, the dummy is a plaster replica of a human head and can endure noise volumes that would injure a human ear.

Armored Boots
Flexible steel mesh is being used in woodsmen's boots to provide protection against accidental cuts or slashes from flying axes.

only 1 material has all 4

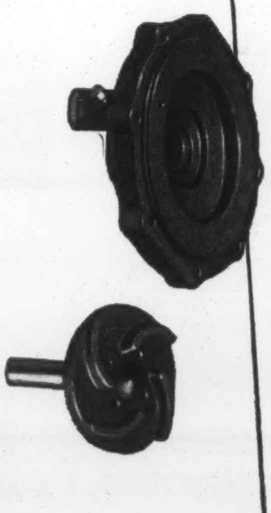


1 CORROSION RESISTANCE
2 STRENGTH
3 DIMENSIONAL STABILITY
4 ECONOMY

...for ACID PUMPS for instance

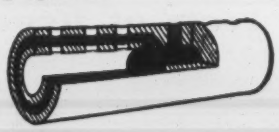
One of the strongest plastics known . . . .Ace Hard Rubber . . . got the nod for the impeller and casings of this acid pump. Why? (1) It's resistant to almost all corrosives; (2) High strength and abrasion resistance; (3) Won't warp or swell; and (4) Costs much less than corrosion-resistant alloys. Typical result: On one job this hard rubber pump handles 12% hydrofluoric acid, turns on and off twice a minute, 24 hours a day, six days a week . . . a mighty tough test for corrosion-resistant materials?

Many other Ace hard rubber compounds are available . . . tensiles as high as 10,000 psi, moisture absorption as low as 0.04%, power factor as low as 0.006, heat resistance to 300 Deg. F. . . . also many new plastics and rubber-resin blends. All Ace compounds are tailor-made to fit the job . . . never *over*-designed. That's why Ace is the *only* material that meets all four big requirements for parts like acid pumps.



and here's a 5th

Hard rubber sleeve provides electrical insulation as well as mechanical and chemical strength in this coupling for electroplating agitator.



80-pg. Ace handbook free to design engineers.

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AMERICAN HARD RUBBER COMPANY
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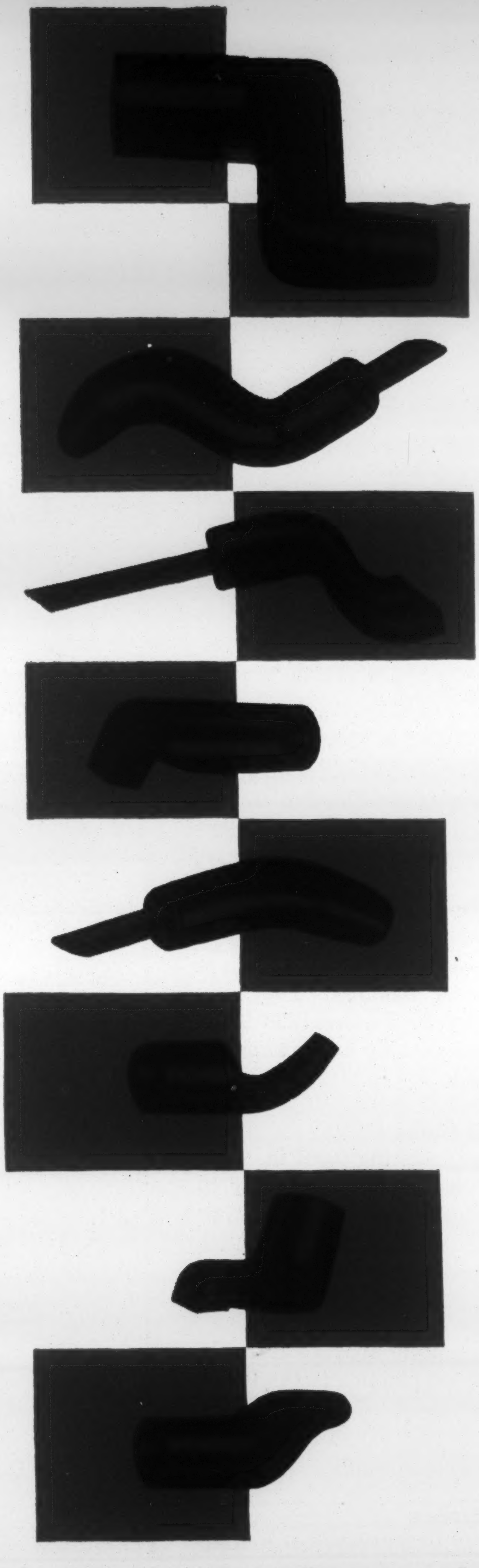

Pick Your Special Electrodes

From Hundreds of Existing MALLORY Designs

Need odd-shaped electrodes for resistance welding around corners, inside channels, or other out-of-the-ordinary places?

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Included in the Mallory line are cold formed single bend and double bend types. Also, cast and forged offset designs. You have a wide choice of nose shapes, tapers and lengths. Bent electrodes are made by an exclusive Mallory cold-forming technique which develops maximum strength and hardness, to assure long life. Both single and double bend types can be supplied with fluted cooling holes and water tubes bent in place*, to assure highly efficient cooling right up to the welding face. All types use specialized alloys and manufacturing methods which Mallory has developed during thirty years of pioneering and leadership in the resistance welding field.

Stock Mallory straight electrodes, holders, seam welding wheels, dies, forgings and castings are listed in the latest edition of our Resistance Welding Catalog. Write today for this valuable reference book . . . and see your local Mallory welding distributor for prompt delivery of high quality welding supplies.

*Patent No. 2,489,993.

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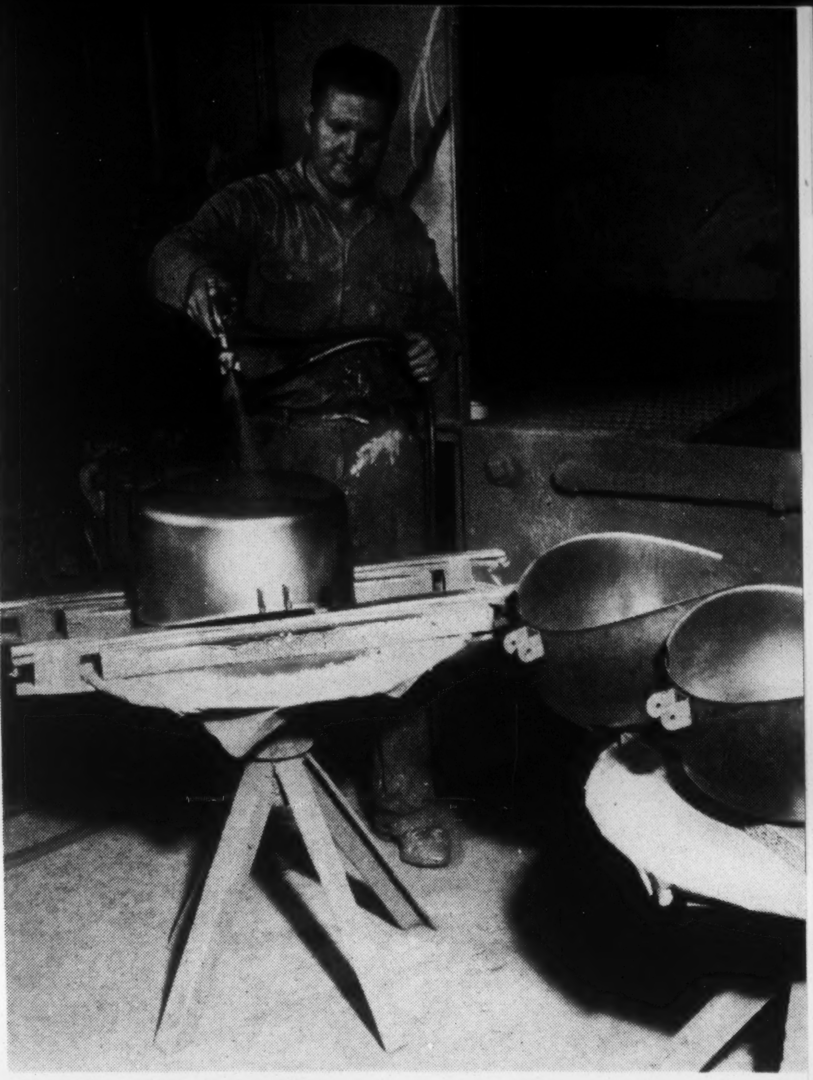
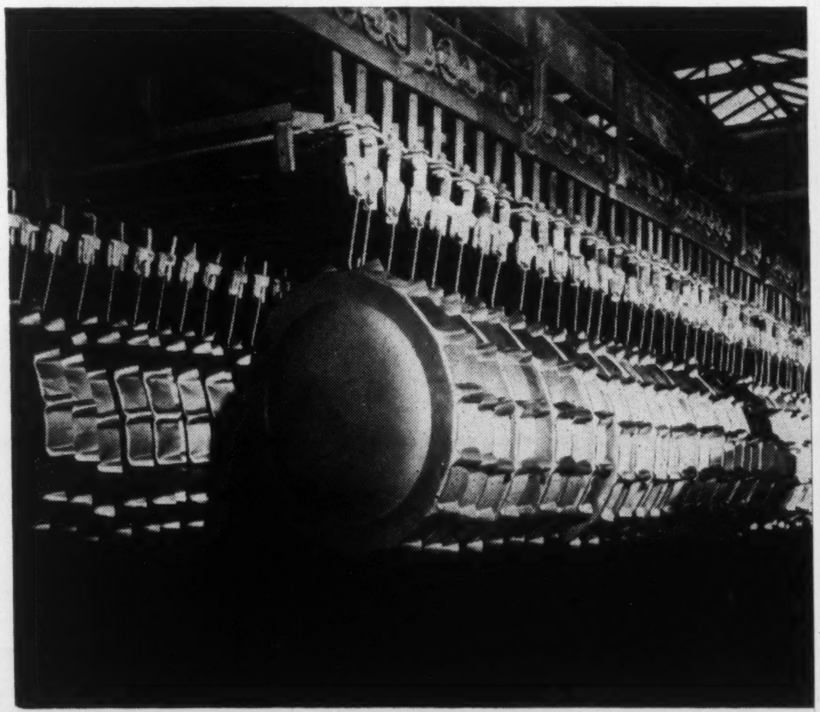
MATERIALS AT WORK

New
and interesting
applications
of engineering
materials



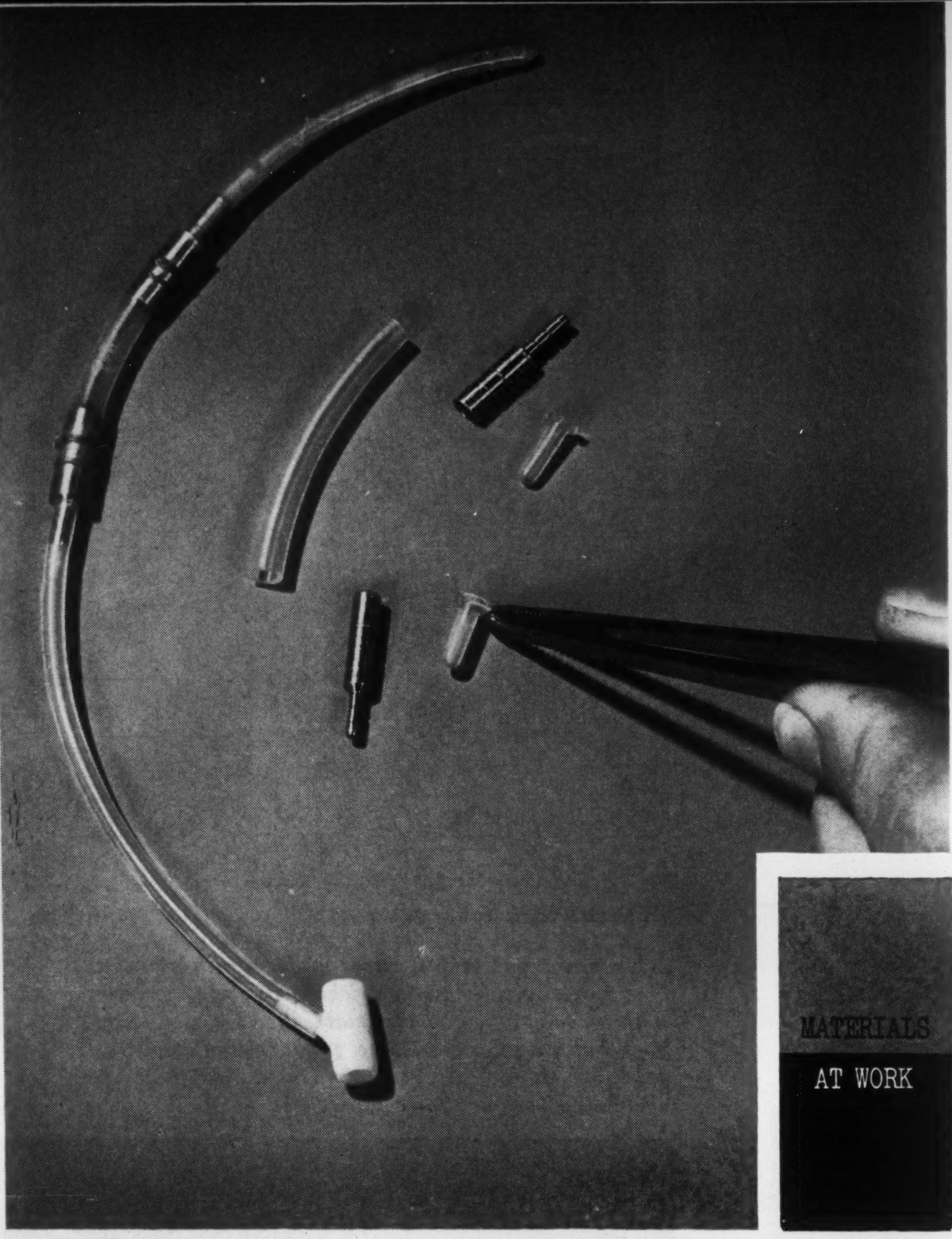
Propane tank covers . . .

. . . and ventilation crowns *for grain storage bins are degreased with trichloroethylene, primed with a compatible zinc chromate, then sprayed with gold butyrate lacquer. The propane tank covers, after air drying only 15 min, get a final coat of clear alkyd lacquer for a high sheen finish.*



Gold butyrate lacquer stays tarnish-free

A gold-pigmented lacquer based on Eastman Chemical's half-second butyrate is now used on process equipment made by Black, Sivalls & Bryson, Inc. The gold coating used previously had tarnished and deteriorated rapidly when exposed to outdoor weather.



MATERIALS
AT WORK

Silicone rubber solves medical problem

Silicone rubber is the essential element in a new automatic brain valve which is expected to save the lives of from 10,000 to 15,000 people yearly.

The valve was specifically invented to treat hydrocephalus, a fatal children's disease in which spinal fluid that normally drains into the system gradually accumulates in the head. Previously a plastics tube was inserted into the brain to drain the fluid to the abdominal cavity. However, when the child outgrew the tube, scar tissue invariably clogged the opening. A better idea was a short tube draining into the jugular vein, but it called for an unbelievably precise plastics valve to prevent backflow of blood.

The new valve uses two side-slit directional nipples of silicon rubber —accurate to 0.0003 in.—inside stainless steel cases (see photo). Connected with a silicone rubber housing, the valves open at the slightest input pressure but provide a double seal against fatal flowback. The rubber material, supplied by Dow Corning Corp., is soft, resilient, translucent and nontoxic. Other advantages: 1) it will not rupture delicate body tissues, 2) it will not encourage growth of tissues by reacting chemically with them, 3) it is easily molded, and 4) it resists sterilization temperatures.

"Do-it-yourself" neon signs

A new concept in the design of neon signs makes use of interchangeable neon-lighted letters which "plug" into a molded phenolic base.

Manufactured by U-Change Neon, Inc. and molded of a Durez phenolic, the sign bases are static-free, lightweight, nonconductive, unaffected by temperature changes and waterproof. In the event of breakage only the individual glass letters need be replaced.

In order to maintain weatherproofing, a pliable seal fits on the electrode and seals off moisture, and caps cover letter sockets not in use. Signs come in six neon colors.

Aluminum wheel better than steel

An aluminum wheel, die cast as an integral unit including hub and brake drum, offers improved brake performance, greater strength and lighter weight compared to a conventional steel wheel assembly.

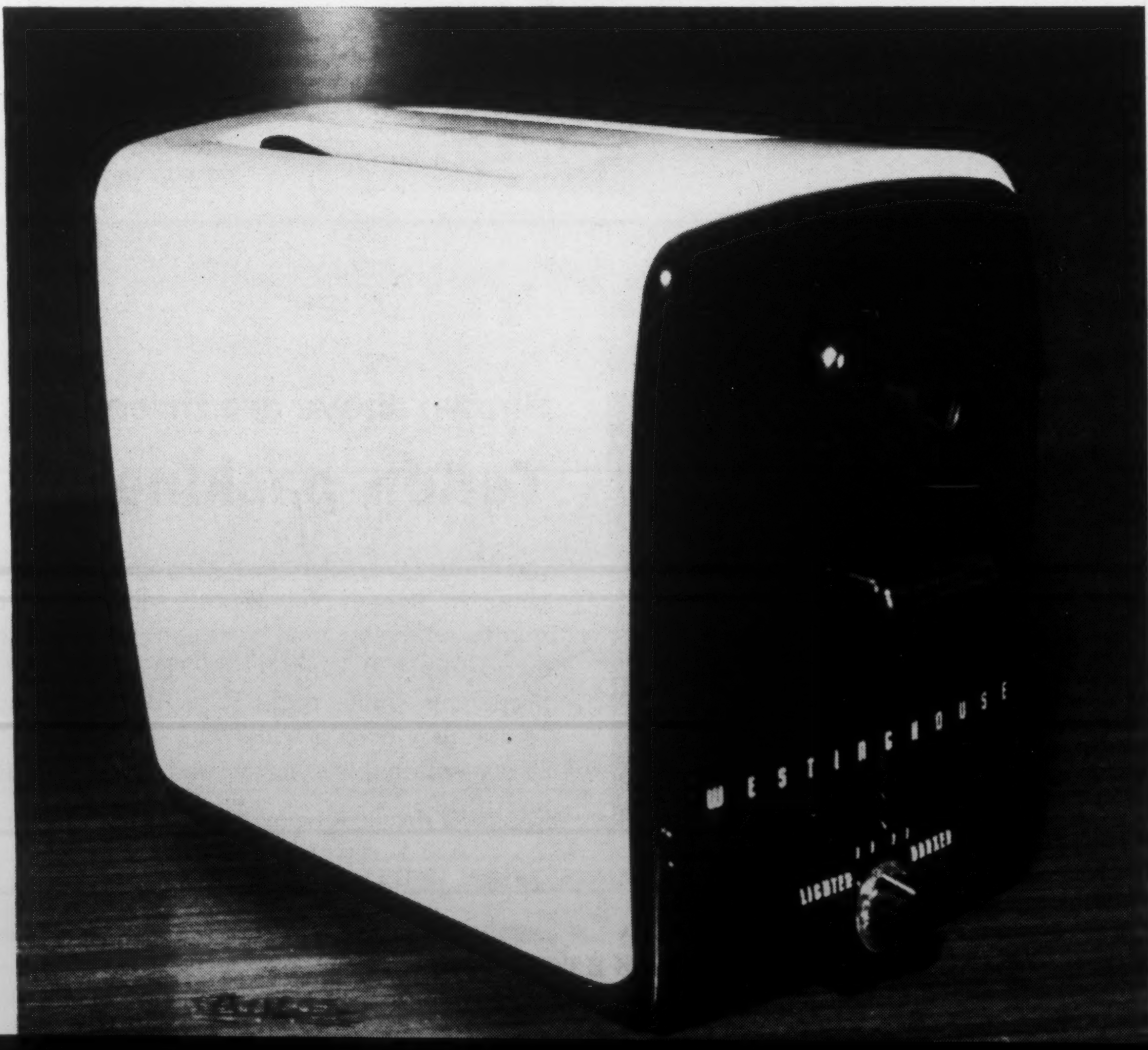
Kaiser Aluminum, who developed it, says tests indicate that the aluminum wheel surpasses accepted standards for wheels in both brake performance and durability. One outstanding advantage of the use of aluminum is that there is less brake fade. This is attributed to aluminum's rapid heat dissipation and to design features that provide a more direct heat-flow path to the cooling area. Radial ribs on the surface of the wheel establish direct air flow over the periphery of the drum in addition to providing rigidity.

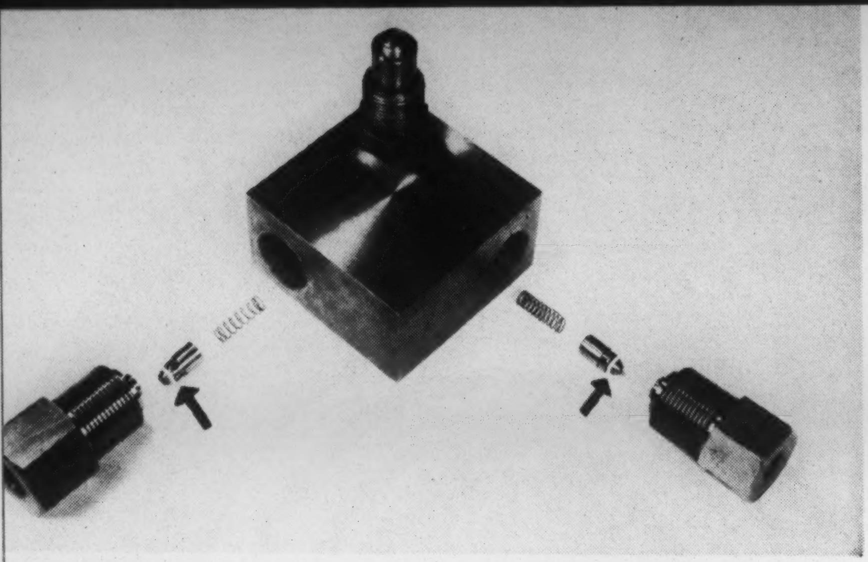
The braking surface of the wheel can be either a metallurgically bonded iron liner, a cast-in iron liner, or a metallurgically bonded metal spray liner. The wheel, complete with 14-in. dia steel rim, weighs only 30 lb as compared to 42.6 lb for a comparable steel wheel, hub and brake drum assembly.

Porcelain enamel used for toaster

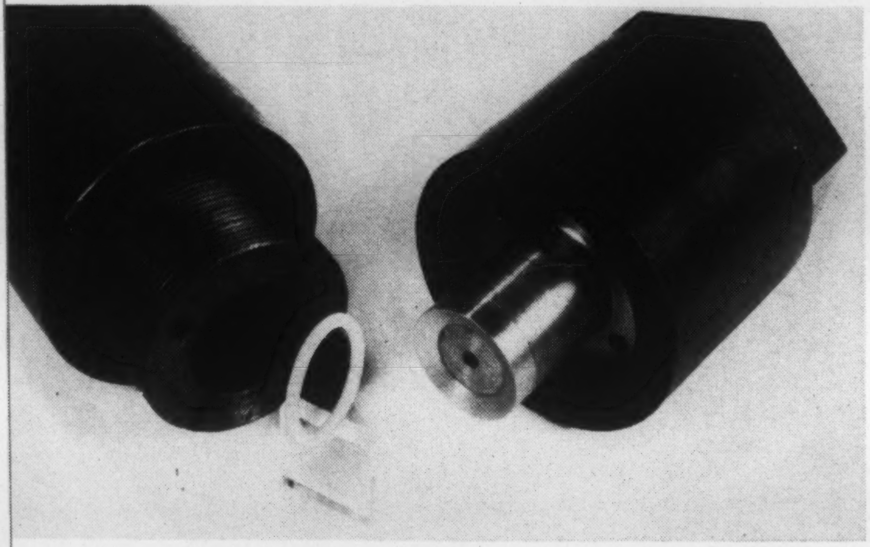
In the toaster shown at the right, a porcelain enamel coating was successfully fired at 1300 F to 0.032-gage steel. The coating has a maximum thickness of 0.008. The firing operations on both ground and cover coats were accomplished in the same furnace conveyor at the same temperature.

Developed by Westinghouse Electric Corp. and the Irvite Corp., the new low-firing enamel offers the design engineer considerable flexibility in the design of small appliances. For one thing, thinner gage steel can be used without fear of buckling; in addition, extremely thin coatings are possible.

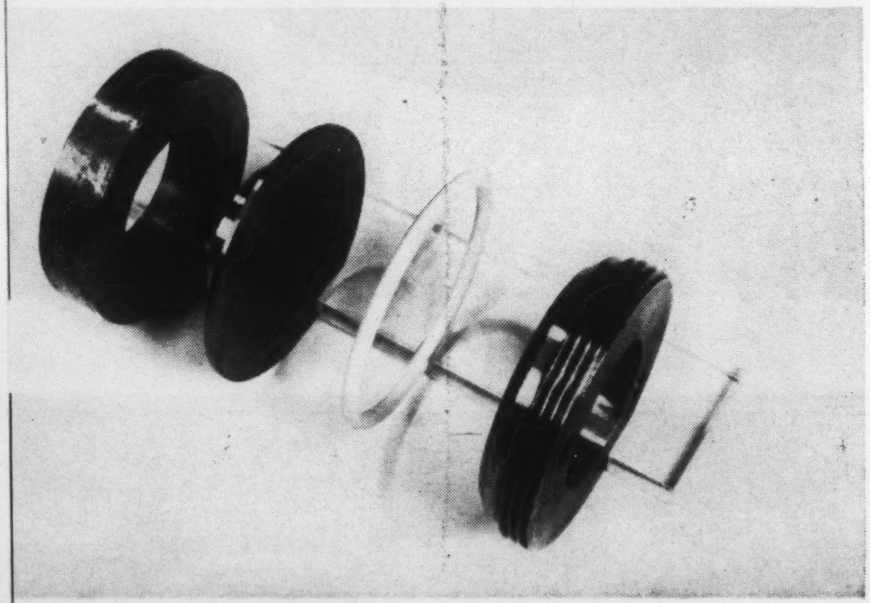




Poppet valve*—The use of PTFE packing rings in poppet valves makes it possible to pump organic liquids and catalyst solutions which would swell and disintegrate other synthetic elastomers customarily used in poppet valves. However, PTFE is a thermoplastic and it requires special treatment: when the packing ring is forced into the retaining groove, it is deformed by stress. This strain is removed by heating the completed assembly at 350 F for 30 min. When prepared in this manner, poppet valves operate satisfactorily in 15,000-psi pumps.*



Self-sealing closure*—This packing ring is used in a self-sealing closure which holds 22,500 psi pressure in a 1-in. dia chemical reaction vessel. The packing ring is placed in the 45-deg angular space between the flanged tube liner and the beveled head button. Initial sealing is accomplished by hand torque on the head nut. Thereafter the self-sealing principle applies and increases the tightness of the seal in proportion to the increase of pressure in the vessel.*



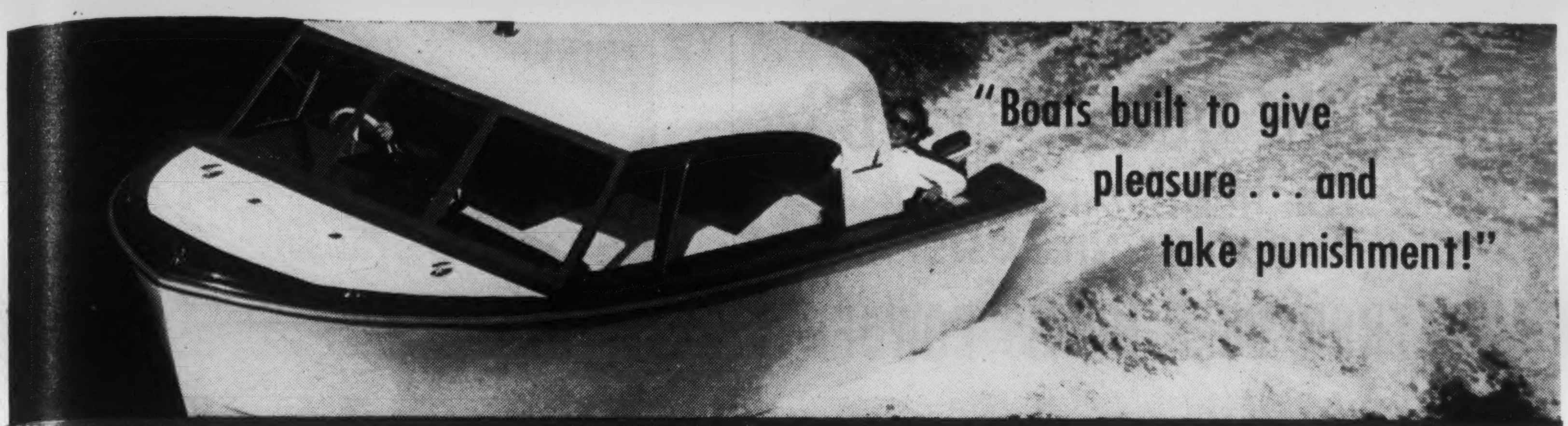
Rupture disk closure*—A rupture disk closure assembly consisting of a shear block, a rupture disk, a 2¼-in. dia packing ring of PTFE and a beveled retaining ring was installed in the pressure side of an autoclave bottom cover. The initial seal was made by hand torque applied to the retaining ring. The high pressure seal was made by increasing the internal pressure in the autoclave. The same PTFE packing ring was used 110 consecutive times.*

MATERIALS
AT WORK

Shown above are three uses of . . .

Teflon packing rings

Teflon (polytetrafluoroethylene) is now being used for packing rings in poppet valves and self-sealing closures in high pressure pumps and chemical reaction vessels. In addition to eliminating metal-to-metal contact, PTFE offers a combination of outstanding properties which make it particularly suitable for this application: 1) stability over a wide range of temperatures, from –100 to 300 F, 2) exceptional strength, and 3) excellent resistance to chemicals and water.



● Bumps and bruises that would often splinter an ordinary craft are shrugged off by these sturdy boats made with RCI POLYLITE polyester resin. Plastic Fabrications, Inc., Miami, Florida, reports that the inherent resiliency of RCI POLYLITE reinforced with fibrous glass allows a hull to "give" under pressure instead of offering stiff resistance — thus improving the overall strength and safety factor of their products.

In addition, a molded boat permits more attractive and complicated hull and deck structure — usually expensive features — at reasonable cost . . . and eliminates sharp edges that are dangerous in angry waters.

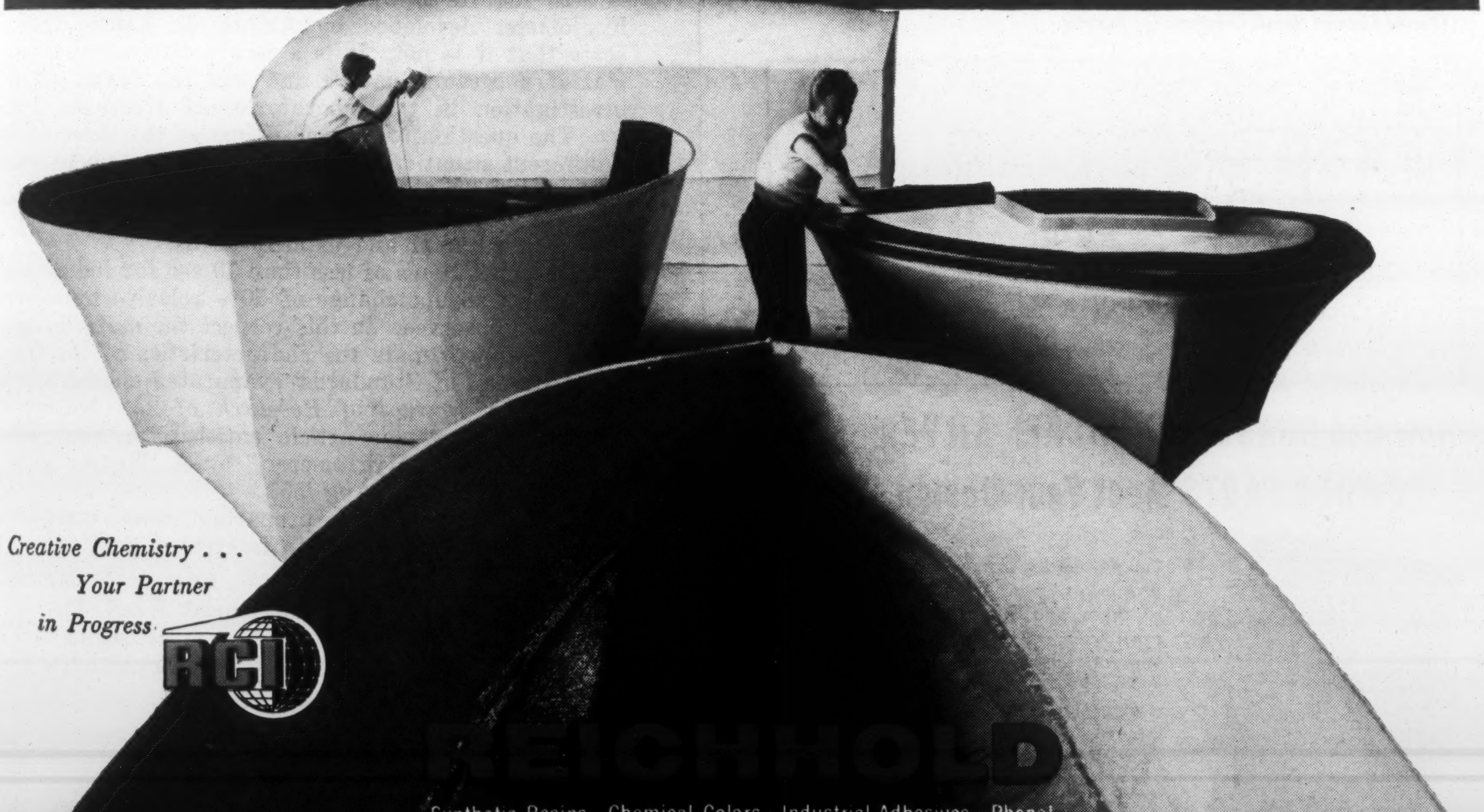
"In production, our primary requirement is a base material with consistent formulation," says J. A. "Woody" Woodson, Plastic Fabrications' president, in explaining why his firm uses RCI POLYLITE. "The curing and weathering characteristics must not vary from batch to batch. If a resin does not cure, our time and labor is lost and the section must be discarded."

"Another 'plus' for Reichhold POLYLITE," continues Mr. Woodson, "is *dependable* distributor arrangements. Our POLYLITE orders are delivered *on time*, so that costly production delays are a thing of the past."

Products possessing the unique advantages possible with RCI POLYLITE — lightweight strength, durability, and easy maintenance — are becoming increasingly popular and profitable in today's market. For additional information about how RCI POLYLITE can be incorporated into one of *your* products by laminating, molding or other plastic applications, write for free *Booklet A*.

Constructed economically with

UNIFORM QUALITY POLYLITE RESINS



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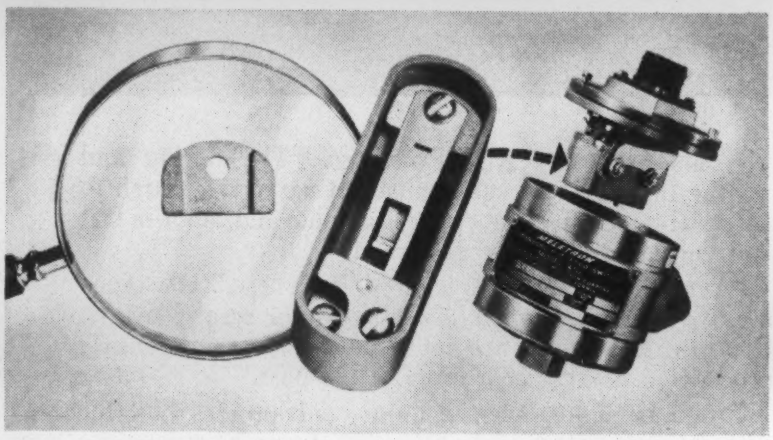

Design requirements for these automatic electric controls are very rigid because of exposure to extreme temperature, humidity, dust, and vibration in all types of aircraft and industrial equipment. The heart of this Pressure Actuated Switch is the contact element that can be set to a specified change in pressure and then relay the change to an outside electric circuit.

BRASS sinterings were chosen by Meletron, pioneers in the manufacture of Pressure Actuated Switches, for this switch contact because of high electrical conductivity and corrosion resistance. Their fabricator* met the high performance standards of the industry at a low unit cost and, equally important, at a low tooling cost.

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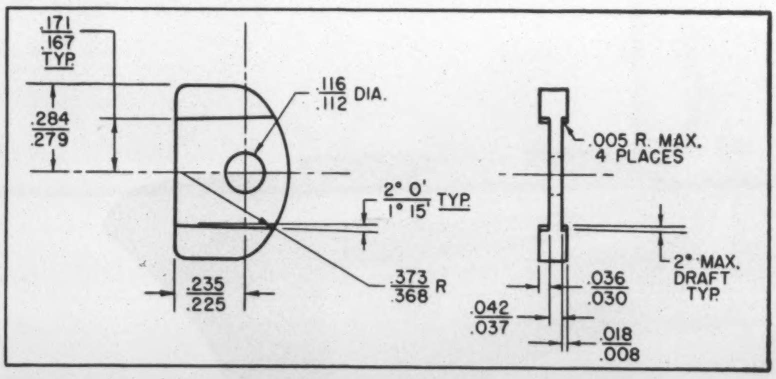

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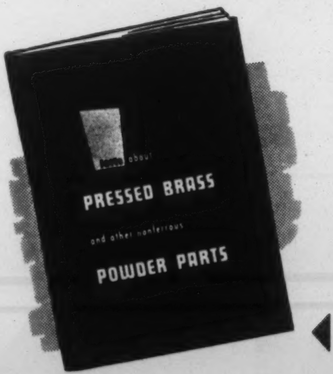
POWDER PARTS Meet Your Design Needs?



For detailed information on the design, properties, production and application of brass and other nonferrous powder parts you should have a copy of our manual. It will give you 20 case histories of brass and nickel silver powder structural parts to assist in evaluating this means of production in terms of your particular needs.

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Letters to the Editor

Humidity indicator questioned . . .

To the Editor:

We are interested in an item in the November issue of MATERIALS & METHODS. It appeared in the "Materials Outlook" section and concerned a ceramic that indicates humidity change.

The response time indicated is not very fast. Most government specs require a response time of 10 sec, although we must define what response time is. We wonder if this is not the carbon black hygrometer developed by Arthur D. Little for the Signal Corps five or six years ago.

ROBERT G. CLARK
Clark & Co.
Salisbury, Md.

. . . and now clarified

To the Editor:

In regard to whether this is the carbon black hygrometer developed by Arthur D. Little, I can state that it is not. It is a newly discovered material of a ceramic nature and was the result of an investigation in the laboratories of Horizons, Inc.

The question of response time of the detector is a different situation, and our original statement was misleading. This situation arose because of the way we defined response. We have now restated it in more conventional and explicit terms.

Response times of less than 10 sec for indicating 90% of an abrupt change of 50% relative humidity have been observed. In this respect the material appears to approximate the characteristics of the National Bureau of Standards' evaporated elements reported in a *Journal of Research of the National Bureau of Standards* article entitled "A Fast Responding Electric Hygrometer," by A. Wexler et al (vol. 55, no. 2, p 71, Aug '55).

We are at present preparing more complete technical data for release to interested parties.

EDWARD F. MAYER
Department Head, Physics
Horizons, Inc.
Cleveland, Ohio

We're out of step, it seems

To the Editor:

In the January, 1957, issue of your fine magazine there appears an article entitled "Stepped Extrusions—A New Metal Form," by a member of Kaiser Aluminum and Chemical Corp. Both the title and the subhead contain extremely misleading information.

Although we may be measuring time by different yardsticks, we don't think you properly can consider stepped extrusions as a new metal form. An article entitled "Stepped Extrusions" by Kirby F. Thornton

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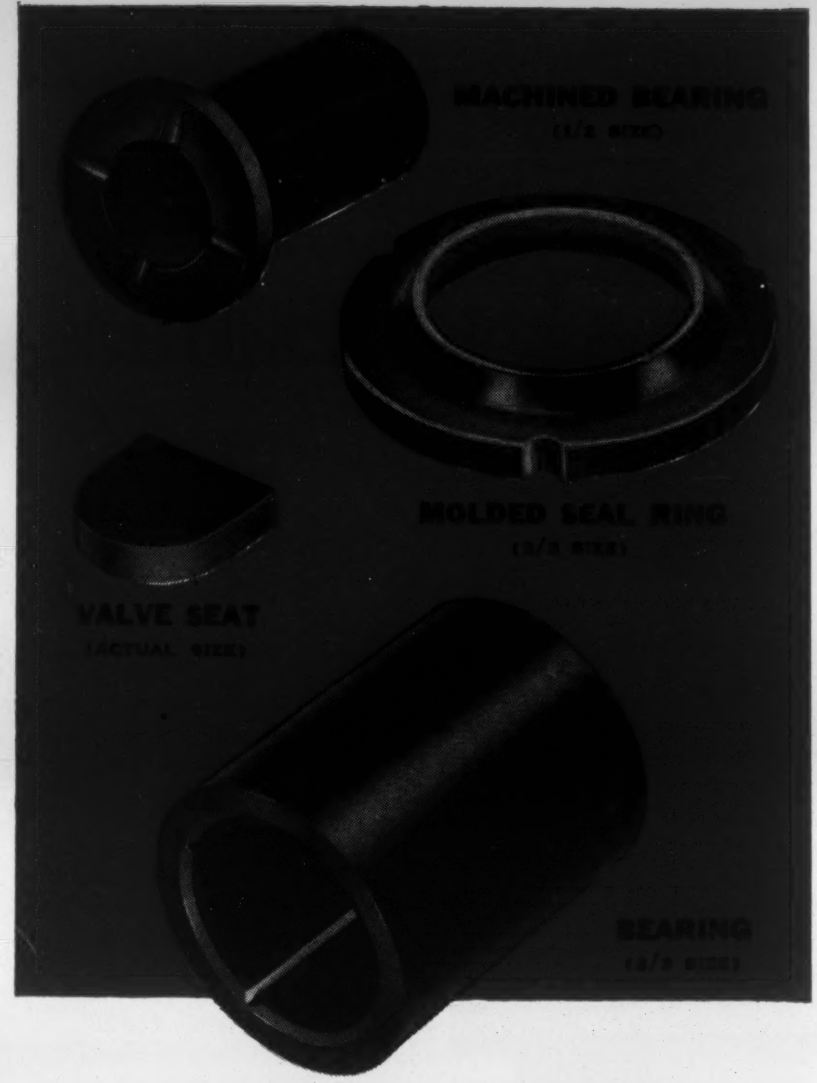

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Letters
to the Editor

(*Mechanical Engineering*, July '44, p 443) reported Alcoa's activities in developing and producing stepped extrusions.

Your subhead states it is *now* possible to obtain an aluminum extrusion having two or more different cross sections. Naturally, an extrusion with one step will have two different cross sections. This type has been common at Alcoa since 1944.

Regarding two, three or more steps, your article says merely that it *may* be possible to produce an extrusion with more than one step. In 1944 Mr. Thornton stated that it is technically feasible to produce extrusions with as many steps as might be required. Since extrusions containing more than one step could have been produced in 1944, it is improper to suggest that such an extrusion is *now* possible.

We merely want to keep the record straight, and since Alcoa pioneered the development of stepped extrusions, I'm sure you can appreciate our position. And I want to emphasize that the objection is to the title and subhead, and not to the information restated in the article.

William K. Kinner
Public Relations Dept.
Aluminum Co. of America
Pittsburgh 19, Pa.

We must admit that we were not aware of the facts stated by Mr. Kinner, and we take this opportunity to call the previous literature cited to our readers' attention.

Bouquet for the prices department

To the Editor:

As a faithful reader of Materials & Methods I would like to congratulate you on the new and logical presentation of your publication, which increases its use and readability.

Your new section on prices was of particular interest to me, especially the prices of nonmetallics, which, to my knowledge, are not to be found anywhere else in an organized form.

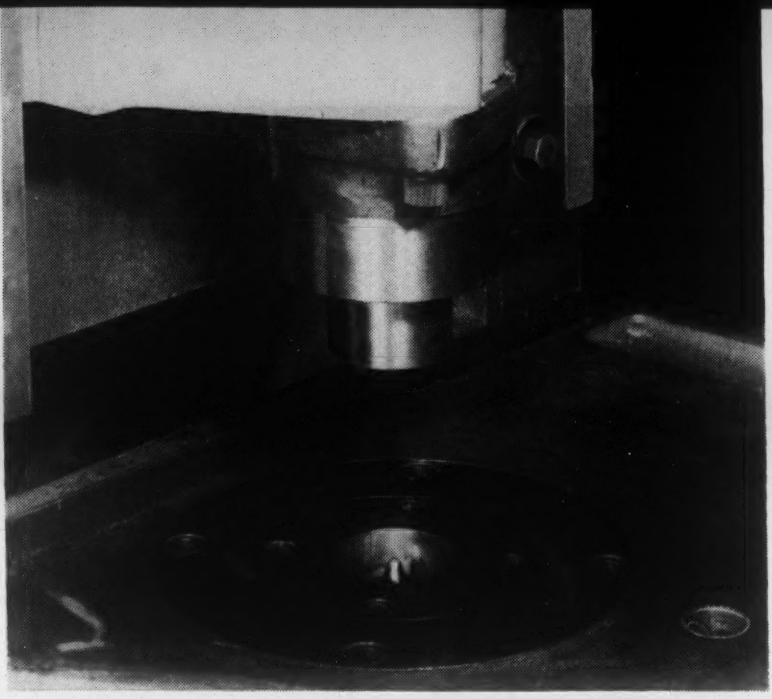
I should like to submit two suggestions for your consideration with respect to plastics prices in particular:

1) It is my hope that you will eventually be able to do away with the vagueness attendant upon the quotation of a range of prices rather than specified prices. This will no doubt take place as your list becomes more detailed, yet I trust you will make an effort to follow the prices of a few typical formulations rather than those of a host of different subtypes.

2) I believe it would also be very useful for your readers to have some idea of the past evolution of specified plastics prices. This might take the form either of a table or a graph.

I trust you will take these suggestions as an expression of my appreciation for the work you are doing.

J. H. Robert
Aluminum Union Ltd.
Montreal, Canada



Preview

Metal Powder Show Annual MPA Meeting

"New Horizons in Powder Metallurgy" is the theme around which the Metal Powder Assn. will conduct its 13th annual meeting at the Drake Hotel in Chicago, Apr 30-May 1.

This year the meeting will have two types of technical sessions: there will be four powder metallurgy sessions on Tuesday and Wednesday and two special sessions on ferrites and electronic cores on Tuesday. Highlight of the technical sessions will be a panel discussion on presses for compacting metal powder.

The Metal Powder Show, at which latest developments in materials, equipment and parts will be exhibited by more than 25 leading manufacturers, will be open from 9 a.m. until 6 p.m. on both Tuesday and Wednesday. A cocktail hour and banquet will be held Tuesday evening.

A detailed program of the technical sessions and a list of exhibitors are given below.

Program

Tuesday, April 30

9:00 a.m.

Metal Powder Show exhibit opens

9:30 a.m.

(two concurrent sessions)

Powder Metallurgy—Ballroom

9:30—"Activated Sintering," M. Eudier, La Métallurgie des Poudres

10:00—"Production and Characteristics of Chemically Precipitated Nickel Powder," K. O. Cockburn, R. J. Loree and J. B. Haworth, Sherritt Gordon Mines, Ltd.

10:45—"Production and Characteristics of Chemically Precipitated Copper Powder," V. S. Ryan, Whitaker Metals Corp.

11:30—"Current Developments in the Rolling of Both Ferrous and Nonferrous Powders," J. D. Shaw and W. V. Knopp, S-K-C Research Associates.

Ferrites and Electronic Cores—Goldcoast Room

9:30—"How to Take Advantage of Magnetic Core Materials," J. A. Roberts, A. Schmeckenbecher and G. Ludewig, Antara Chemicals Div., General Aniline & Film Corp.

10:15—"Magnetic Cores in Miniature Electronic Circuits," D. M. Hodgin, Collins Radio Co.

(continued on p 21)

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Resistox Metal Powders meet all standards for purity and consistency. And a much greater resistance to oxidation gives *Resistox* 5 to 10 times the stability of ordinary metal powders!

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2:00 p.m.
(two concurrent sessions)

Powder Metallurgy—Ballroom

2:00—"Fiber Metallurgy," C. H. SUMP and W. POLLACK, Armour Research Foundation

2:45—"Primary Consideration in the Design and Use of Sintered Metal Parts," R. TALMAGE, Powder Metallurgy Consultant

3:30—Panel Discussion on Presses for Compacting Metal Powders. Moderator: J. D. SHAW, S-K-C Research Associates. Panel: W. GORT, Arnhold Ceramics, Inc.; B. B. BELDEN, Baldwin-Lima-Hamilton Corp.; J. J. KUX, Kux Machine Co.; C. C. SUTINEN, Mannesmann-Meer Engineering & Construction Co.; G. G. KARIAN, F. J. Stokes Corp.; H. E. ELLIOTT, Watson-Stillman Press Div.

Ferrites and Electronic Cores
—Goldcoast Room

2:00—"Characteristics and Applications of Ceramic Permanent Magnets," C. A. MAYNARD, Indiana Steel Products Co.

2:45—"Characteristics and Present Requirements of Ferrites," R. D. HARRINGTON, National Bureau of Standards

3:15—"Latest Developments in Magnetic Storage and Switching Applications," J. W. SCHALLERER, General Ceramics Corp.

4:00—"Thermal Expansion of Ferrite Materials at Temperatures Near the Curie Point," W. R. BUESSEN, Pennsylvania State Univ. (research sponsored by Stackpole Carbon Co.)

6:30 p.m.
Reception and cocktail hour—Grand Ballroom

7:30 p.m.
Banquet—Goldcoast Room

Wednesday, May 1

9:00 a.m.
Metal Powder Show exhibit opens

Powder Metallurgy—Ballroom

9:00—"New Developments in Metal Powder Filters," L. H. MOTT, Cuno Engineering Corp.

9:30—"New Developments in Diamond Products Using Metal Powders," L. KUZMICK, J. K. Smit & Sons, Inc.

10:15—"Metal Powders in Brazing and Soldering," P. D. JOHNSON, Glidden Co.

(continued on p 23)

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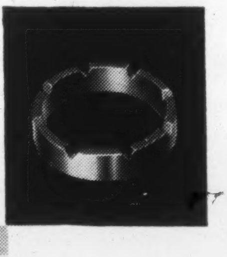

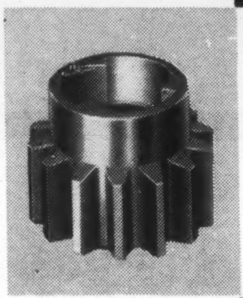

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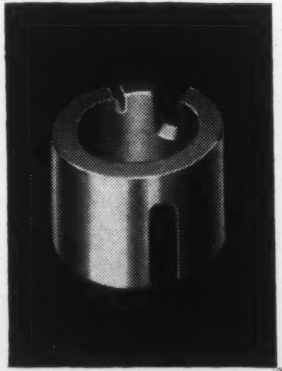

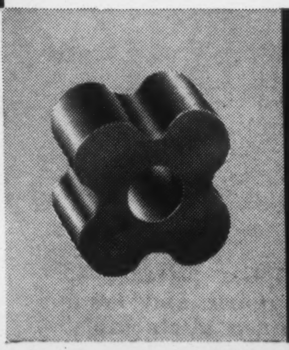

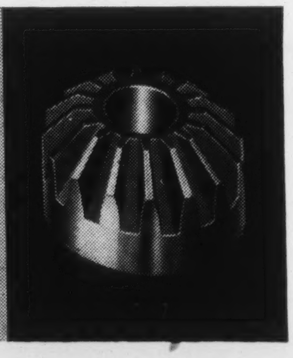

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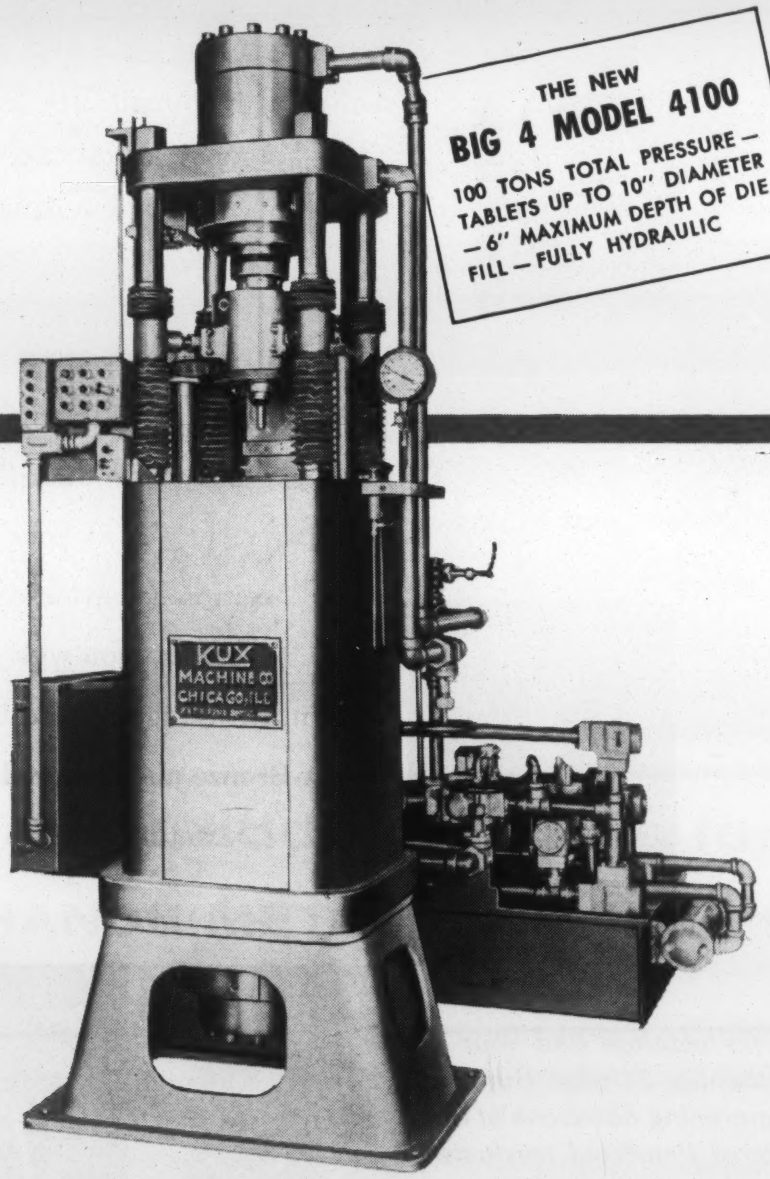

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- **Completely Automatic**—pushbuttons operate machine continuously or through a single cycle with an automatic stop position.
- **Accurate Dimensional Thickness of Tablets**—upper and lower punches come to a positive mechanical stop position, holding thickness of each tablet.
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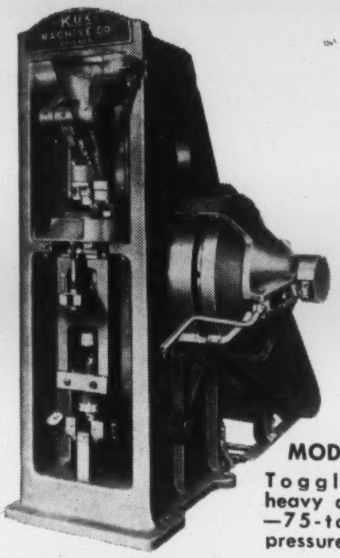
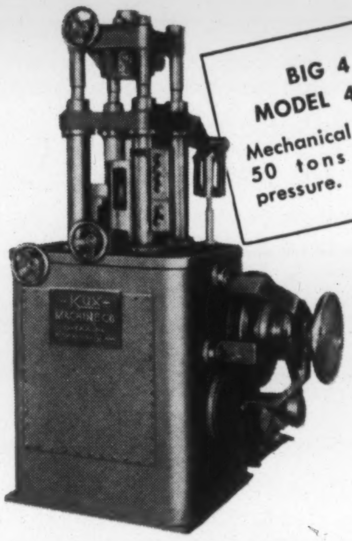


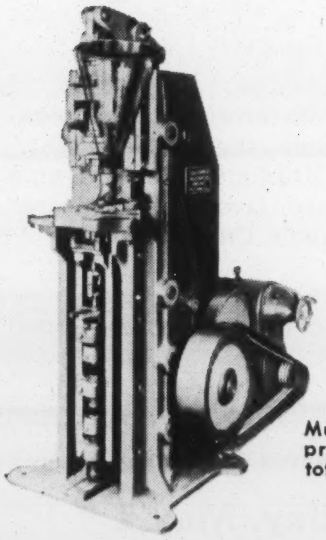
MODEL 65B

Toggle type heavy duty press—75-ton total pressure.



BIG 4 MODEL 450B

Mechanical press 50 tons total pressure.



MODEL 64

Multiple motion press—30 tons total pressure.

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11:00—"Metal Powders in Pyrotechnics and Explosives," J. Sachse, Metals Disintegrating Co., Inc.

2:00 p.m.

Powder Metallurgy—Ballroom

2:00—"Superfine Iron Powders," M. W. Freeman, M. W. Freeman Co., and J. H. L. Watson, Ford Institute for Medical Research

2:45—"Fundamentals of Powder Metallurgy," G. Kuczynski, Notre Dame Univ.

3:30—"The Sintering of Iron-Copper-Carbon," P. Ulf Gummenson, Hoeganaes Sponge Iron Corp.

4:15—"Powder Metallurgy in the Manufacture of Roller Chains," C. L. Richards, Whitney Chain Co.

Exhibitors

Alloy Metal Powders, Inc.
American Society for Metals *(Metal Progress)*
Antara Chemicals Div., General Aniline & Film Corp.
Arnhold Ceramics, Inc.
Arnold Engineering Co.
Baldwin-Lima-Hamilton Corp.
Drever Co.
Easton Metal Powder Co.
Electric Furnace Co.
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Harper Electric Furnace Corp.
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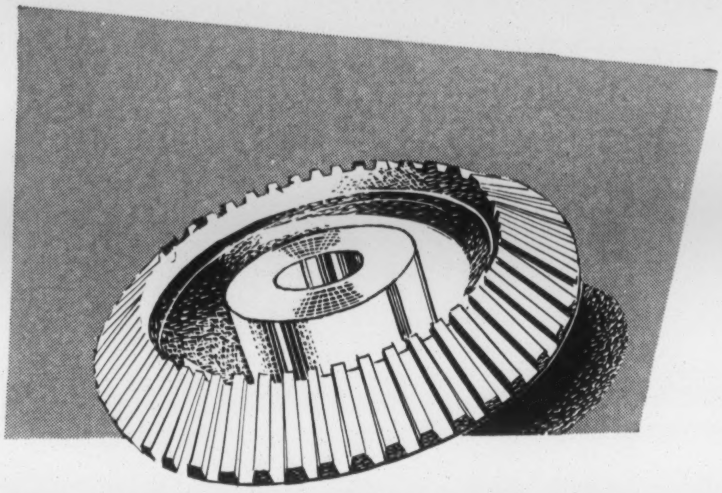
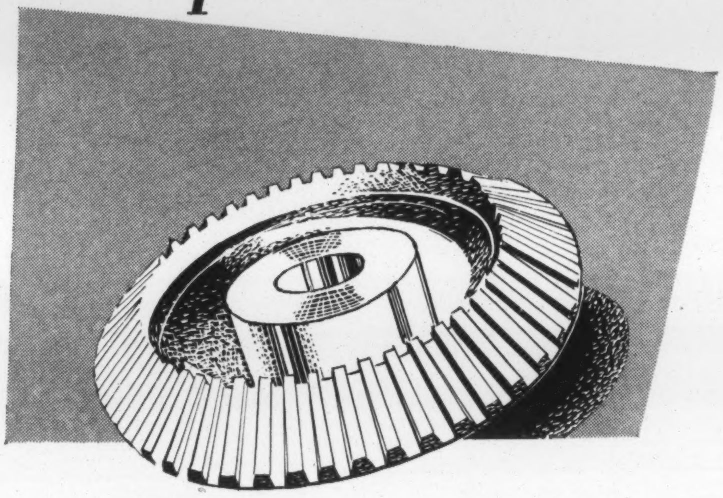


one costs $31.21 per hundred



and one costs $22.51 per hundred

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Elongation — 1%	Elongation — 2.5%
Rockwell Hardness — C34	Rockwell Hardness — C26
Apparent Density — 7.78	Apparent Density — 6.83
Production Steps — Nine	Production Steps — Four

**(7½% addition of 50% chrome/50% nickel, plus 1% carbon)*

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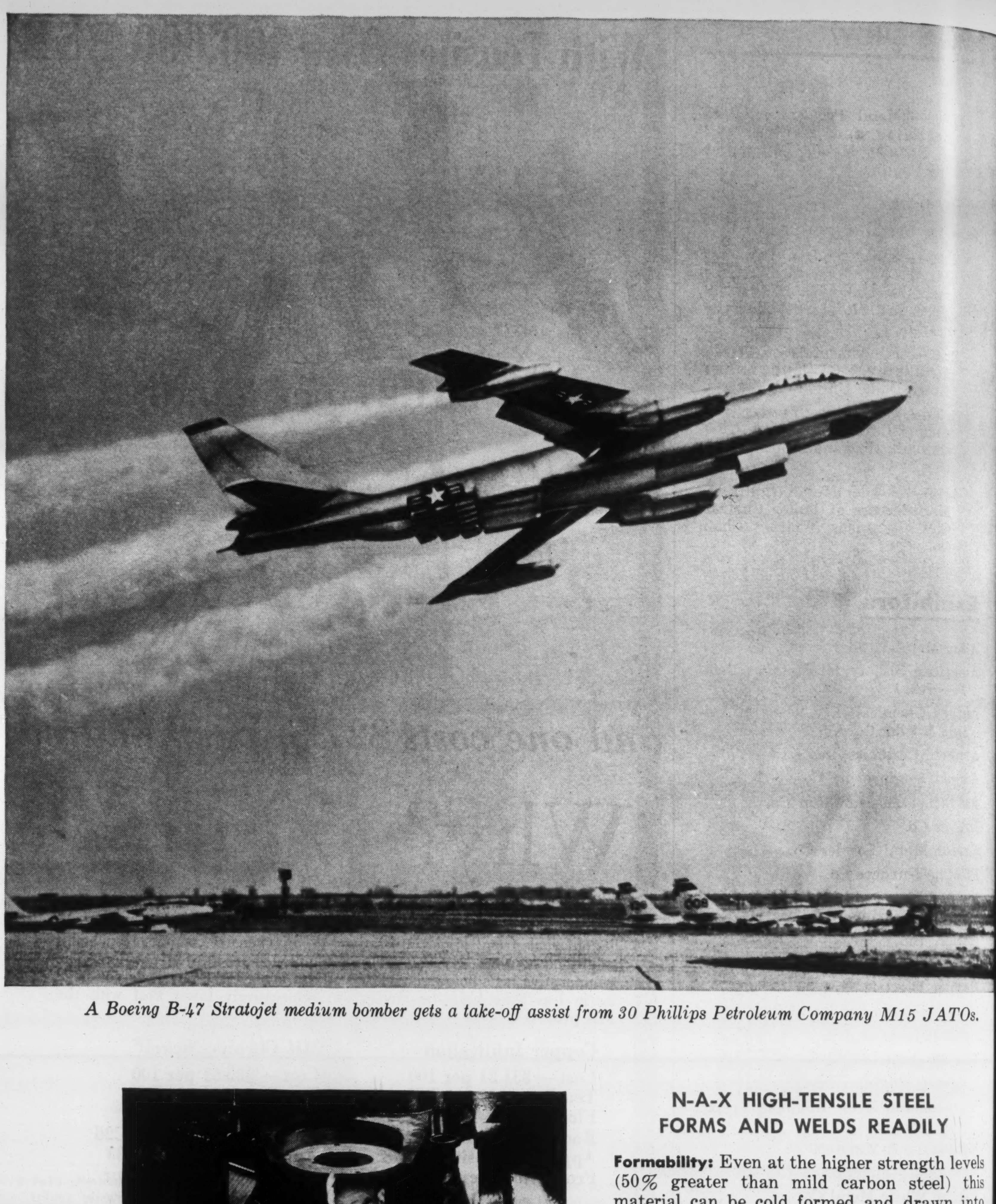
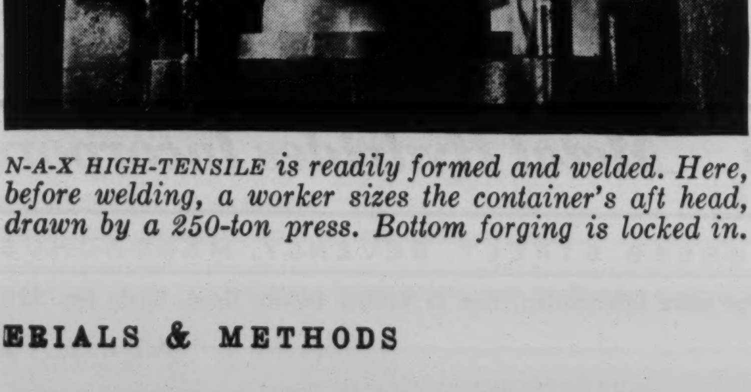


A Boeing B-47 Stratojet medium bomber gets a take-off assist from 30 Phillips Petroleum Company M15 JATOs.



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ONE POINT OF VIEW

Engineering aides: We need more

One of the common complaints of engineers is that they must spend too much of their time performing routine tasks that do not require the talents of a professional engineer. During the past several months we have published letters from readers suggesting that one way to eliminate this inefficient use of engineering manpower is for engineering departments to use engineering technicians or aides.

Roadblocks exist

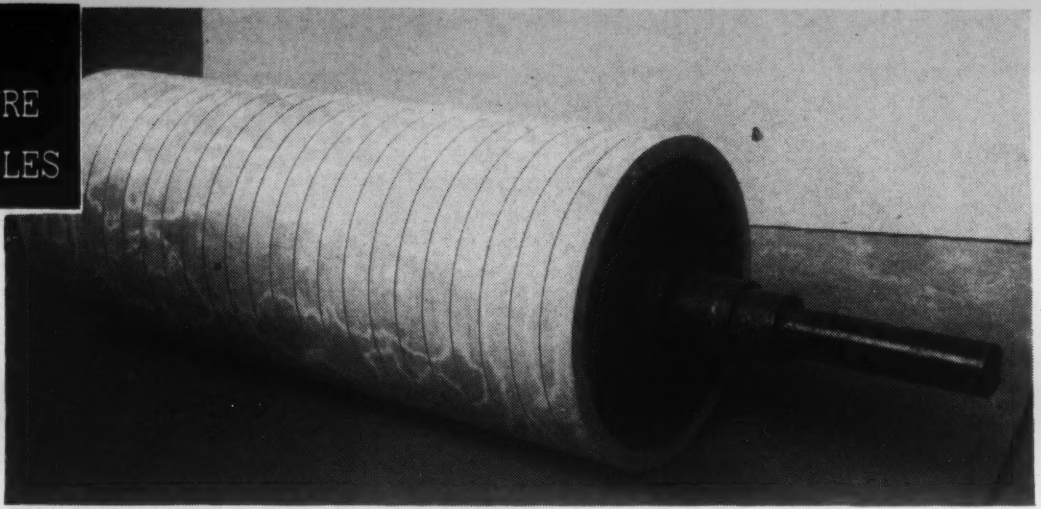
We agree that this is an effective way of conserving our engineers' valuable (and expensive) time. Unfortunately, there are at least two obstacles in the way of wider use of engineering aides by industry. One of these is the reluctance of many companies to make use of them. Much of industry's reluctance stems from lack of knowledge about engineering aides and where and how they can be used. A common misconception is that their training and qualifications are comparable to those of vocational school graduates. But this is not true. Qualified engineering technicians receive at least one full year of post-high school training in an accredited technical institute. The program of instruction is essentially technological in nature and specifically designed to prepare them for work in the field of engineering.

The other, and more serious, obstacle to wider use of engineering aides is the shortage of acceptable training facilities. At present only 32 institutions have curricula that are accredited by the Engineers' Council for Professional Development. Despite the present limited acceptance of engineering aides by industry, these few schools cannot meet the demands for qualified personnel. Demand will increase more rapidly as the rate of our technological advance increases.

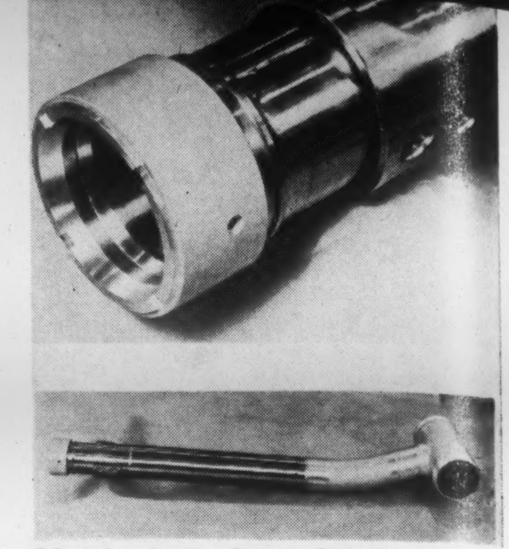
But something's being done

Until recently little time and attention has been given to the subject of engineering technicians. However, in the last twelve months there have been signs of activity. Early last year the Engineers Joint Council sponsored a conference on the engineering technician. Also last year, the President's National Committee for the Development of Scientists and Engineers organized a committee to establish a program for developing more and better qualified engineering technicians. Finally, the Technical Institute Div. of the American Society for Engineering Education has obtained money from the Carnegie Fund to undertake a study of technical institute education.

Activities such as these are a good beginning, and they are indicative of growing interest in the problem. We hope that they will quickly lead to much needed constructive action.



***Tinplating roll**—made of steel-laminate.*



***Shock strut piston head**—made of aluminum-laminate.*

Plastics Laminates Bonded to Other Materials

Thermosetting plastics laminates themselves provide a wide choice of properties but sometimes they work better when combined with other materials such as steel, aluminum or rubber.

by **Norman A. Skow,** *Director of Research, Synthane Corp.*

■ The advantages, as well as the limitations, of high pressure plastics laminates are rather well known (see M&M, Feb '57, p 121-140). But combine them with other materials such as steel, aluminum, copper, rubber, cork, plastics films or vulcanized fibre and the result is essentially new materials combining the desirable properties of plastics laminates with those of the material to which it is bonded. Thus the designer can specify a combination of physical, mechanical and electrical properties that is unavailable in a single engineering material.

Specific design advantages offered by combination laminates include:

1. Better strength-weight ratios.
2. Increased resistance to corrosion and chemicals.
3. Greater range of electrical characteristics.
4. Dimensional stability over a wide temperature range.
5. Increased rigidity and strength for soft sealing materials.
6. Improved bearing surfaces.
7. Greater range of frictional characteristics.
8. Improved fabrication characteristics, and reduced production costs.

Materials and forms available

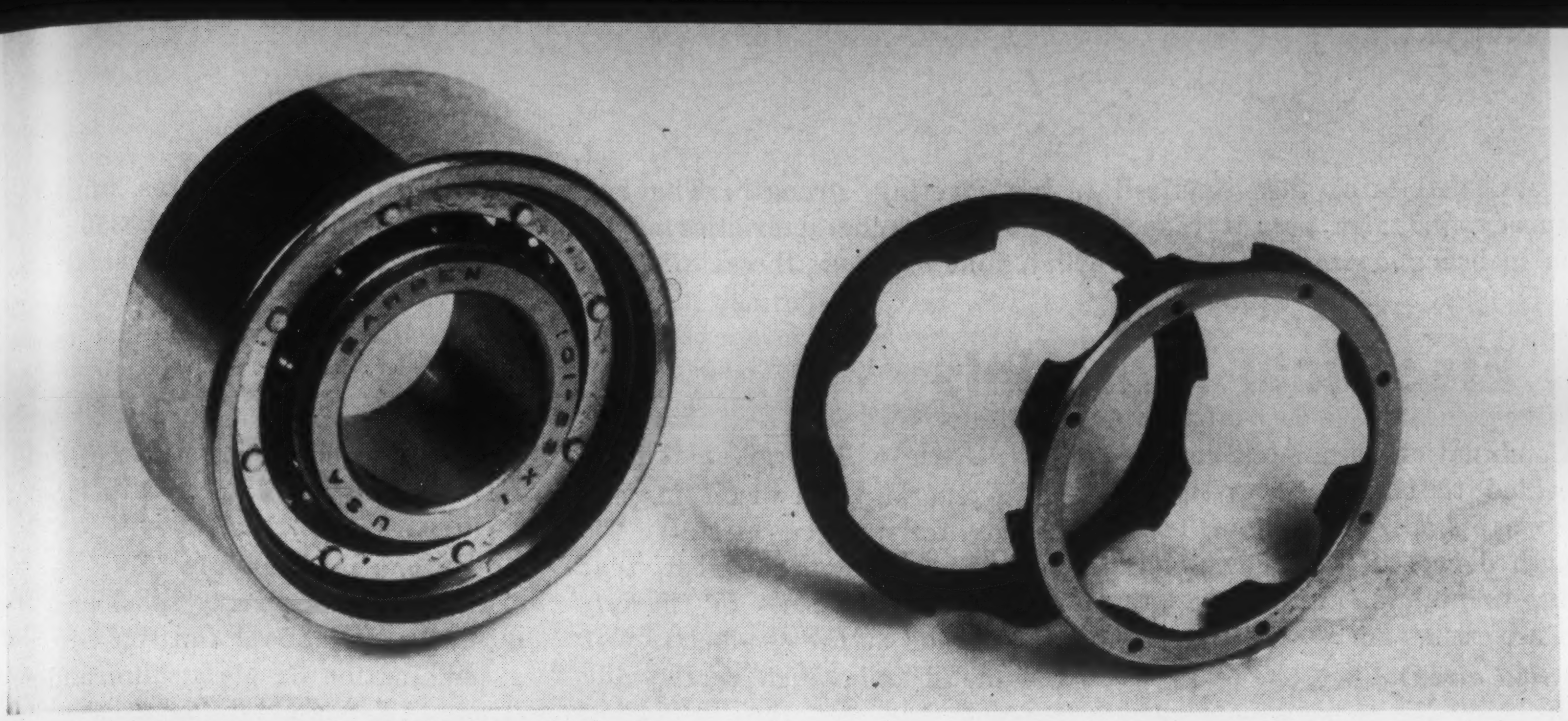
Theoretically any material can be combined with plastics laminates by adhesive bonding. However, because of similarities in design requirements for various types of end uses, several combinations have become somewhat standardized.

The most common plastics laminates used are the paper-base phenolics such as NEMA Grades XXXP, XX, XXP and XP. Grade G-10, epoxy-glass, has received increasing attention for printed circuit applications. Fabric-base phenolics, such as Grades C and L, are used where impact resistance is required or where impregnants such as graphite or molybdenum disulfide are used to provide self-lubricating qualities. For specialty applications, melamine laminates may be specified where better arc or alkali resistance is required, or silicone laminates where exceptionally high temperatures are to be encountered.

The most common materials supplied in combination with plastics laminates are: copper, natural and synthetic rubbers, cork, steels, aluminum alloys, vulcanized fibre, and polyester and cellulose acetate films. Two grades of plastics laminates can be bonded together where the properties peculiar to each are required.

Adequate bonding of combination laminates is always an important consideration. However, for certain types of materials adhesive formulations have been developed to the point where the actual strength of the bond is seldom a problem.

Combination laminates can be specified in sheet, rod or tube form. In sheet form, the plastics laminate can be specified on one or both sides, or sandwiched between lamina of the other material. Where a tubular form is used, the combination material usually consists of a plastics laminate covering a metal tubular core. In rod form a solid core of one of many types of metal can



***Bearing retainers**—made of aluminum-laminate.*

be covered with a laminate.

Sizes of materials available are limited by the facilities of the materials supplier. Synthane, for example, is producing combination sheets in standard 36 x 36-in. sizes. Facilities are also available for producing sheets in 36 x 72 and 24 x 96-in. sizes. Tube o.d.'s range from ¼ to 26 in., and lengths up to 36 in. In some sizes lengths up to 96 in. can be provided, and greater lengths can be obtained by making use of mechanical joints.

Use them as 1. Structural Materials

Steel or aluminum in combination with plastics laminates is usually used where structural strength is required. Sometimes Grade XX paper-base laminates are used with metals, but more commonly either coarse or fine-weave cotton fabric laminates are used for optimum strength.

Plating rolls

A variety of design requirements exist in the different types of rolls used for electrolytic tin plating of steel strip. The rolls control a 42-in. wide continuous strip of steel which is pickled, plated and polished while traveling at speeds up to 4100 ft per min.

Developed in cooperation with Steel Plant Equipment Corp., the rolls replace the conventional rubber covered rolls. They consist of steel cores covered with fabric reinforcement impregnated with several types of resins. The selection of the fabric and the resin is dependent on the needs of each individual roll. Bridle rolls, which prevent the steel sheet from buckling as it uncoils, have hard, abrasion resistant surfaces. Hold-down rolls are made to withstand effects of sulfuric acid at temperatures up to 200 F. This laminate also insulates the roll from the electric current, preventing electrolytic deposition of tin on the rolls. Wiper rolls are formed with a surface soft enough to remove moisture, yet firm enough to resist wear.

In service, the laminate-covered rolls last more than three times longer than the rubber-coated rolls. Also, in comparison with the rubber rolls, they are more resistant to acids; denser, eliminating embedment in the rolls of foreign particles which might mar the surface of the plate; and tougher, reducing the extent of edge cutting and gouging that results in excessive vibration and chatter during the high speed plating operation.

Shock strut piston heads

A fabric-base phenolic laminate bonded to a 2024 aluminum tube forms a hydraulic piston head in aircraft shock struts developed by Cleveland Pneumatic Tool Co. The shock strut utilizes piston-activated hydraulic fluid and compressed air to absorb the impact of a plane's initial contact with the ground. The pistons in the strut must be lightweight, mechanically strong, shock resistant, impervious to hydraulic oils and stable over a wide temperature range. The most important reasons for using a plastics laminate bonded to aluminum are to eliminate metal-to-metal contact between the head and the cylinder and to prevent scoring of the cylinder wall by impurities in the hydraulic fluid. The laminate is sufficiently resilient to permit impurities to embed themselves in the laminate instead of abrading the sealant wall. This combination material is being used as piston heads in sizes ranging from 3 to 10 in. dia.

Precision bearing retainers

Retainers for precision bearings produced by the Barden Corp. also make use of the stability, strength and light weight of an aluminum-laminate combination. Retainers are machined from a combination sheet consisting of a plastics laminate with an aluminum facing bonded to one surface. The retainers maintain the required accuracy and also permit reduction in bearing size while retaining riveting strength. The heat dissipation characteristics of the aluminum permit the retainers to be used at temperatures up to 300 F continuously and 350 F intermittently.

2. Electrical Materials

Combination laminates can be specified to obtain a variety of electrical properties ranging from a high degree of surface conductivity to high dielectric strength and arc resistance.

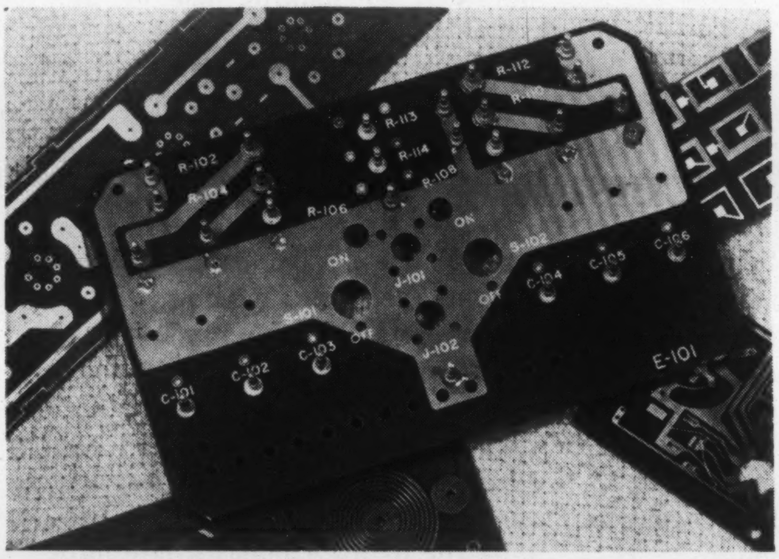
Printed circuits

Probably the most widely used electrical combination material is the copper faced laminate used for printed circuits. Since a great deal has been published about this type of application (see M&M July '55, p 94; Feb '57, p 136). little space will be given it here.

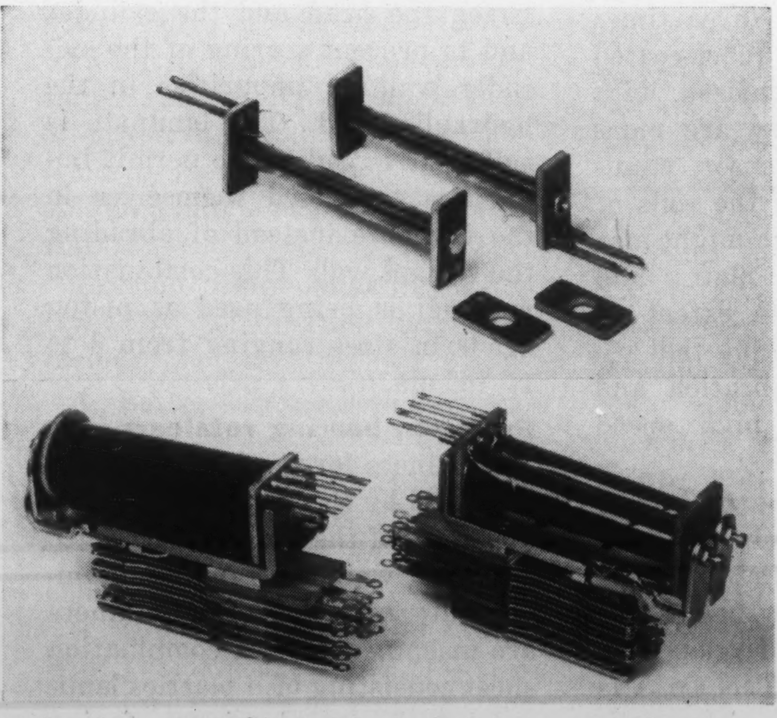
In general, when specifying materials for printed circuits, the engineer should remember that over-all requirements of the circuit depend on the conductivity of the metal foil which carries the current and on the insulation resistance, chemical resistance, moisture absorption characteristics and mechanical properties of the base laminate. The adhesive must provide good bond strength and high surface resistivity as well as resistance to blistering when the circuit elements are soldered.

Telephone relay spools

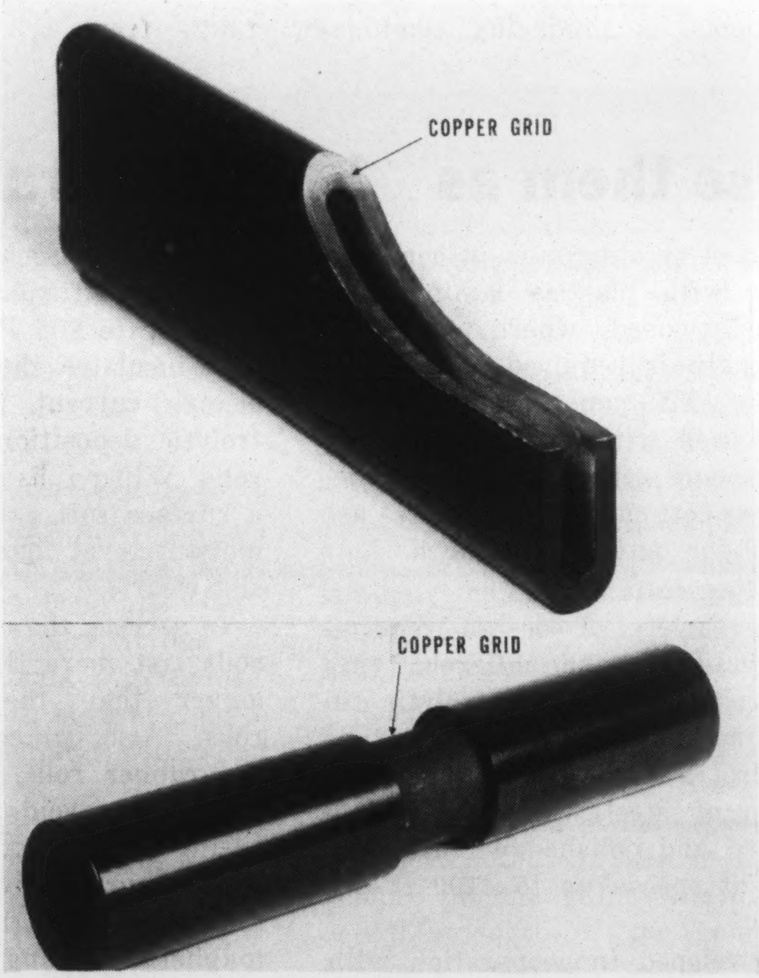
In a telephone relay spool produced by Stromberg Carlson Div. a combination of Mylar film and Grade XXP laminate is used as end plates. The plastics laminate provides required structural strength as well as dielectric properties; the polyester film serves as a moisture barrier. Barriers are necessary to prevent



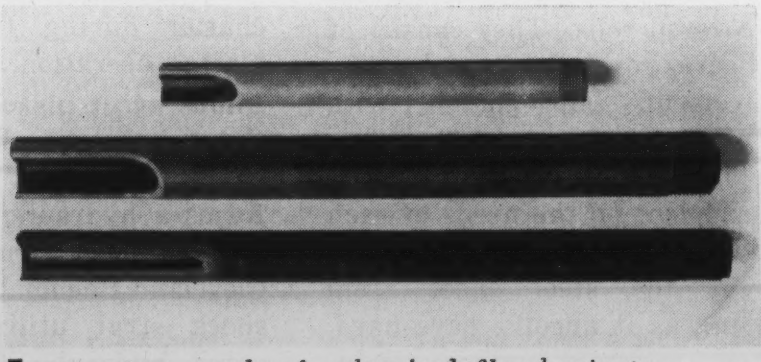
Printed circuit—*made of copper-laminate.*



Relay spool end plates — *made of polyester film-laminate (top). Below is finished telephone relay spool.*



Circuit breaker bushings—*made of copper-laminate.*



Fuse cases—*made of vulcanized fibre-laminate.*

corrosion of the wiring on the spool. Acetate washers were originally used; however, the combination of film and laminate as an integral unit provides a substantial labor saving in production.

Circuit breaker bushings

In bushings for three-phase circuit breakers manufactured by I-T-E Circuit Breaker Co., graphite-impregnated plastics laminates and copper are used to provide a combination of insulation and conduction. A graphitized phenolic layer is deposited on the i. d. of the laminated tube to provide corona protection when a copper protector bar is inserted. The laminated tube is then wound in the conventional manner, and at a specified position in the wall copper foil approximately 0.0015 in. thick is inserted to supply the necessary ground shield. The tube is machined to expose a portion of the ground shield which is then coated with graphitized resin to provide positive contact. The ground shield permits equalization of the electrical charge throughout the bushing.

Fuse cases

Electrical distribution transformers serving residential areas are protected by power fuses rated up to 12,000 amp interrupting capacity. Power fuses made by the R. & I. E. Equipment Div. of I-T-E Circuit Breaker Co. are protected by a fuse case made of phenolic tubing lined with vulcanized fibre. When the elements melt and the ends arc under short circuit or overload conditions, the fibre is heated and generates sufficient gas to snuff the arc. The fibre also prevents the arc from "tracking." The plastics laminate protects the fibre from moisture and contributes the mechanical strength necessary to protect the fibre lining from distorting or rupturing.

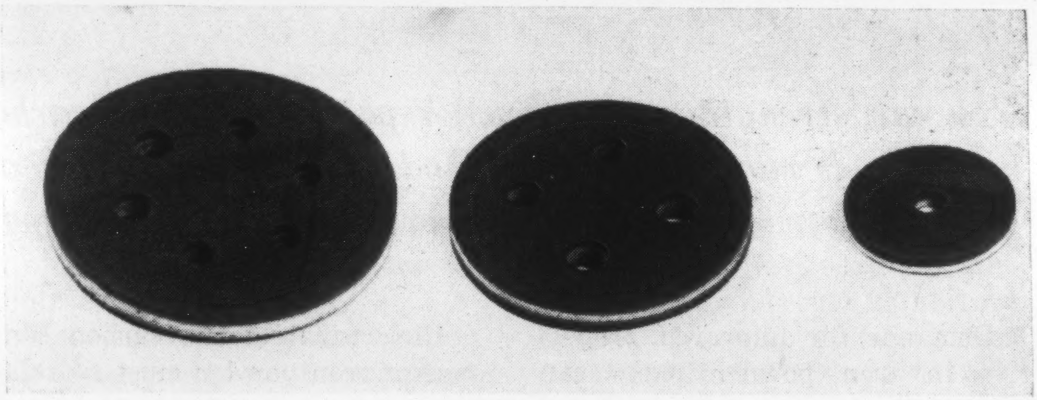
3. Sealing Materials

Laminates bonded to cork or to a variety of types of rubber can be used where soft sealing characteristics must be coupled with rigidity. In addition to Red Buna S, chloride and sulfate-free Buna S are available in combination with plastics laminates where this type of purity is essential. Other rubbers that can be combined with plastics laminates include Buna N, a nitrile type rubber with good oil resistance and freedom from chloride and sulfates, and neoprene, which has good oil and heat resistance.

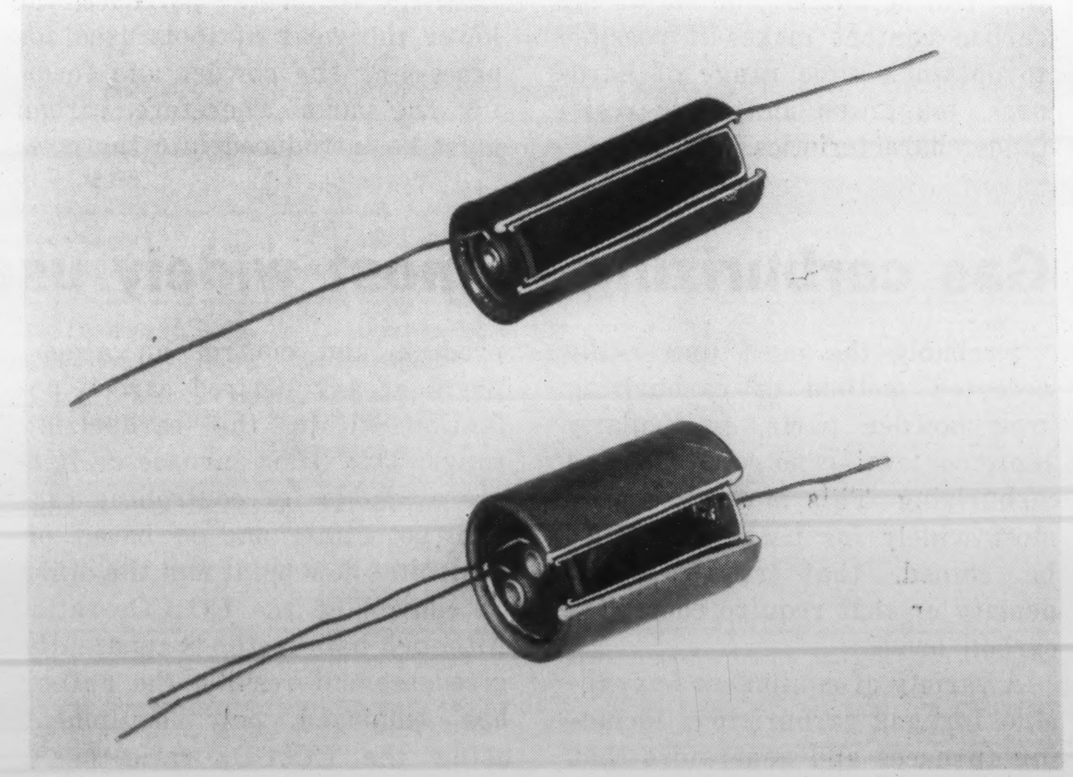
Condenser seals

Washers consisting of Grade XP laminates bonded to Red Buna S rubber are used by Ajax Condenser Co. as end seals for aluminum cans encasing electrolytic condensers and capacitors. The most common washer consists of a 3/64-in. thick laminate bonded to a 1/32-in. thickness of rubber. The laminate side of the washer rests on a bead on the interior wall of the can and the aluminum is spun down into the rubber, forming a hermetic seal. Terminals entering through punched holes in the washer are riveted, also providing hermetic seals against the rubber.

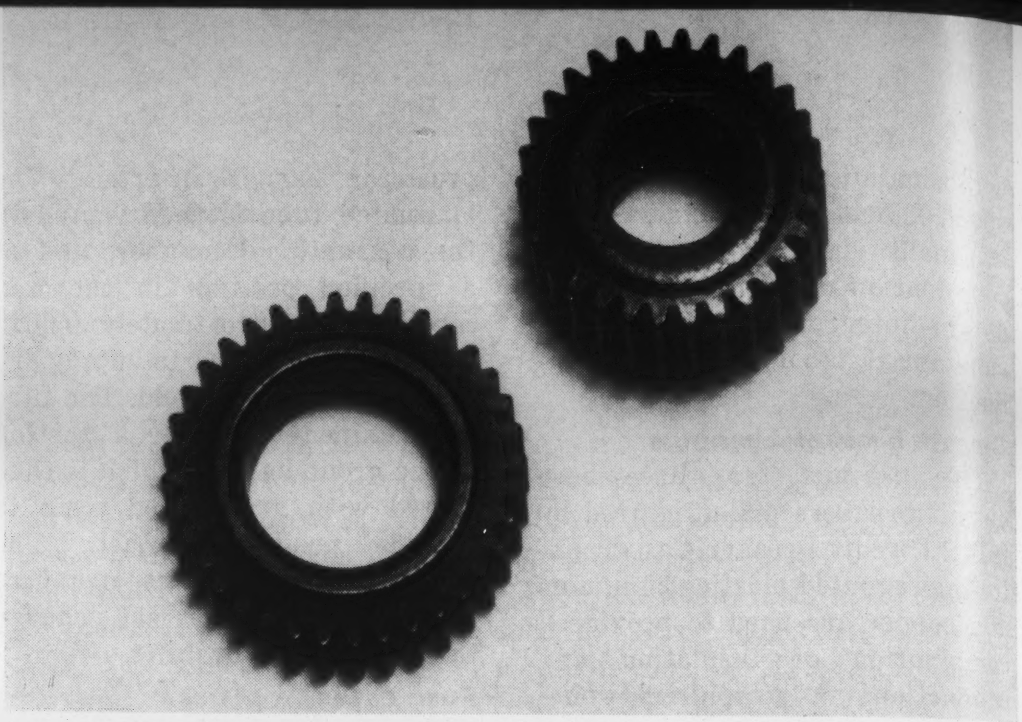
In oil field capacitors neoprene is used instead of Red Buna S because of its superior oil resistance. Prior to the introduction of these rubber-laminate washers, wax was used to seal capacitors and condensers. Labor costs were relatively high and wax seals tended to deteriorate over long periods of time.



Condenser seals—*made of rubber-laminate (above). Cut-away views of assembled condensers are shown below.*



Six gas carburized parts



1 ***Commercial class 4 gears*** *pressed from electrolytic iron powder to a minimum density of 7.5 gm per cu cm, carburized at the 0.90% carbon level to a depth of 0.030 in., and tempered to Rockwell C45-50.*

What you should know about Carburized

You can strengthen iron powder parts by adding carbon, but there is more than one method. The method you choose will have an important effect on the properties of the finished part.

■ Demands for improved properties in iron powder parts can frequently be met by modifying the composition of the part. Carbon is the most effective element that can be added; control of the carbon content makes it possible to obtain a wide range of hardness, toughness and wear resistance characteristics.

Unfortunately the carbon content of iron powder must be relatively low so that the particles are soft and ductile enough to be easily pressed into shape. In addition, the softer the particles, the lower the wear of tools used for processing the powder and forming the parts. Therefore, carbon must be introduced into the powder mixture or into the part after it has been pressed.

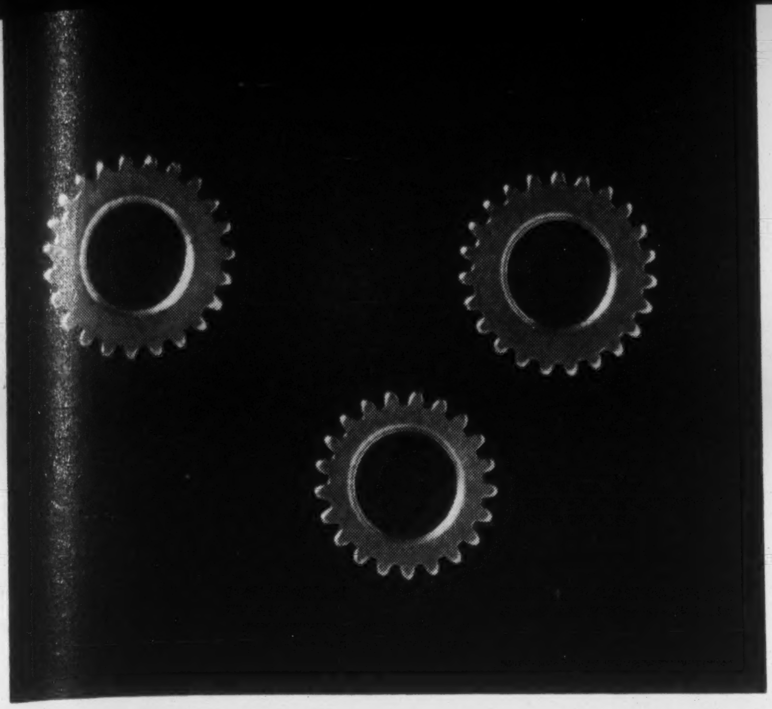
There are several methods of introducing carbon into a powdered iron part. They include carburizing by gas, liquid salt bath or pack methods, and mechanical mixing followed by heat treatment. Each has its particular advantages and limitation.

Gas carburizing is most widely used

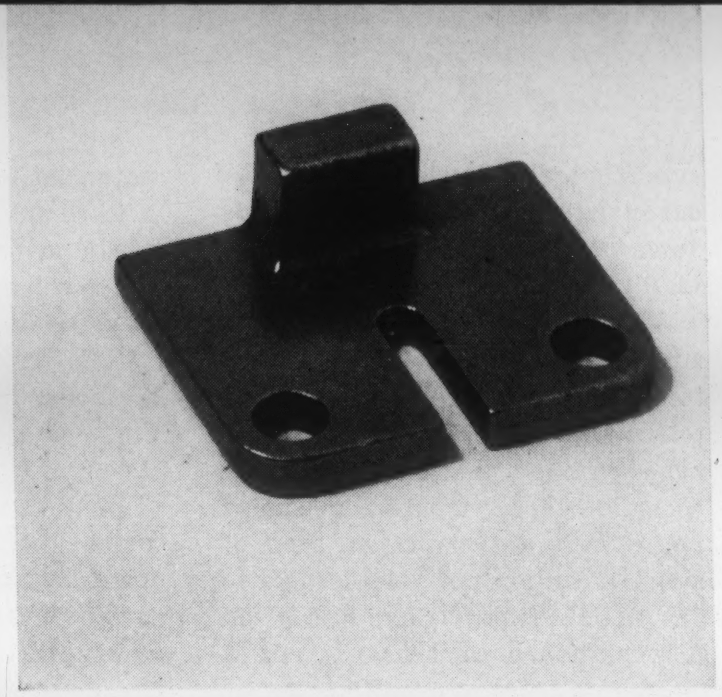
Probably the most universally accepted method of carburizing iron powder parts, particularly those containing no copper, is gas carburizing. This method is used most widely for parts that must be coined, that require high density or that require controlled carbon levels.

A variety of equipment is available for gas carburizing, including furnaces and generators that produce and control an atmosphere at any desired carbon potential within the carburizing range. Two basic furnace designs are available for controlling carbon potential; one is based on control of dew point and the other on control of the $CO:CO_2$ ratio. Although both methods apparently give excellent results, the author has employed only equipment using the $CO:CO_2$ ratio as a method of carbon potential control, specifically a Leeds and Northrup furnace having Microcarb control. This type of furnace is very reliable and consistently controls carburization within ±0.03%.

An accompanying table compares the mechanical properties of electrolytic iron parts carburized to several carbon levels with the properties of AISI steels hav-



2 ***Precision class 1 gears*** *pressed from electrolytic iron powder to a minimum density of 7.5 gm per cu cm, through carburized at the 0.45% carbon level, and tempered to Rockwell C48-52.*



3 ***Business machine part*** *pressed from electrolytic iron powder to a min density of 7.1 gm per cu cm and carburized at the 0.90% carbon level to a depth of approx 0.005 to 0.008 in. Full hard surface required for wear resistance.*

Iron Powder Parts

by W. J. Doelker,
Chief Metallurgist, Supermet Div.,
Globe Industries, Inc.

ing similar carbon contents. These figures do not give a true comparison because the metal powder test bars were carburized through only about 80% of the cross section, but they indicate the possibilities. Tensile and yield strengths of the carburized and hardened iron powder parts closely approximate those of the corresponding steels, but their ductility is lower.

Advantages

Clean, uniform parts—Gas carburizing is an extremely clean, uniform method of heat treating iron powder parts. It leaves no salts or other foreign material in the pores — a characteristic of some other methods, particularly on medium or low density parts. The integrated quenching bath usually found with this type of equipment makes it possible to carburize, cool to the proper quenching temperature, and quench the parts—all under the protection of the same atmosphere.

Homogeneity — High density iron powder parts can be homogeneously carburized if they are not so thick that the process is uneconomical.

Carbon control — Any desired carbon level can be obtained through use of carbon potential control equipment.

Close tolerances — In making high density electrolytic iron powder parts, size variations can often be held to very close tolerances. Close dimensional control results from several factors: 1) since these high density parts are solid for practical purposes, uniform expansion occurs on heating, 2) use of a high sintering temperature leaves the parts in a fully annealed and stress relieved

CARBURIZED IRON POWDER PARTS VS WROUGHT CARBON STEELS[a, b]

Material[a]	Heat Treatment	Tensile Strength, 1000 psi	Yield Strength, 1000 psi	Elong, %	Rockwell Hardness
Iron Powder (0.95%C) AISI C-1095	Oil quenched, tempered at 600 F	170 182	160 119	1 10	C48 C42
Iron Powder (0.95%C) AISI C1095	Oil quenched, tempered at 800 F	138 175	120 112	2 12	C36 C36
Iron Powder (0.95%C) AISI C1095	Oil quenched, tempered at 1000 F	100 158	86 98	4 15	C25 C31
Iron Powder (0.80%C) AISI C1080	Oil quenched, tempered at 600 F	160 189	155 143	4 11	C46 C39
Iron Powder (0.40%C)	Oil quenched, tempered at 400 F	125	104	3	C50
AISI C1040	Water quenched, tempered at 400 F	130	97	16	C51

[a] Iron powder is electrolytic type, pressed to a minimum density of 7.5 gm per cu cm. Carbon contents inficated for iron powder test bars were obtained by carburizing.

[b] Metal powder parts tested on bars having ¼ by ¼ in. cross section; steel properties are for bars ½, 1, 2 and 4 in. round. Data therefore indicate only relative properties of the materials.

condition, and 3) closely controlled carburizing conditions yield uniform and predictable dimensional changes.

Many parts, particularly the smaller ones, are held to a total tolerance of 0.0005 in., and a tolerance of 0.001 in. is commonplace on most parts. For example, a small, heat treated precision gear with a production rate of about a million per year is held to an A.G.M.A. precision, fine pitch gear standard of Class 1, i.e., a maximum total composite error of 0.001 in. and a maximum tooth-to-tooth composite error of 0.0004 in.

Case depth control—It is possible with high density parts to hold the case depth within relatively close limits. With carbon potential control, the case can be held to any given carbon level but, as in all carburizing operations, the level drops from the surface to point of deepest penetration.

Gas carburizing, like other methods, carburizes low and medium density parts all the way through. On medium density parts of heavy section it is possible with carbon potential control to generate a case having a specified carbon level, but the depth cannot be accurately controlled.

Disadvantages

Copper barrier — During infiltration or sintering, any copper that does not alloy with the iron spreads over the surface and acts as a shield that carbon monoxide cannot penetrate. Parts containing copper, whether added to the powder blend or as an infiltrant, will not carburize uniformly because of this shielding effect; the gaseous atmosphere has no stripping effect on copper.

Quenching baths limited — Because of the effect of water vapor upon the carbon potential of the atmosphere, integrated quenching baths in gas furnace units are restricted to oil or liquid salts. However, this limitation is usually not too serious, as there are a variety of oils having quenching rates close to that of water. The majority of powder metal parts are relatively small, and a fast quenching oil will quench them at a rate sufficient to develop the desired hardness.

Liquid carburizing is best for iron-copper parts

Iron powder parts containing copper added either in the powder blend or by infiltration are usually carburized by the liquid method.

Advantages

Copper removal—The salts used in liquid carburizing have a high affinity for copper and strip it from the surface of the iron, thus exposing the surface to the carburizing action of carbon monoxide generated in the salt bath. This is a major advantage because other methods of carburizing are relatively ineffective when used on parts containing copper.

Case depth control—Liquid carburizing can be used very successfully on high density parts to maintain a case depth to a high degree of accuracy.

The liquid method usually carburizes low and medium density parts all the way through because of their porosity. However, the high carburization rate characteristic of liquid carburizing makes it possible to form a carburized case on medium density parts of heavy cross section. The process is not controllable to the extent that specific case depths can be generated and maintained within close limits.

Disadvantages

Salt penetration — The major disadvantage of liquid carburizing lies in the fact that most iron powder parts are porous and allow the liquid salts to penerate into the compact. Upon quenching, the salts solidify, and the nature of the pores makes it practically impossible to remove them from within the part. Carburizing salts are normally hygroscopic, and the water pick-up tends to create an accelerated corrosion condition that often makes it impossible to use the parts. This problem is confined primarily to low and medium density parts; high density parts do not have intercommunicating porosity, and it is possible to wash them completely free of salt.

Lack of carbon control—Carbon concentration cannot be controlled in liquid salt baths, i.e., carburization takes place at a concentration normally somewhat in excess of 1.0%. Where a case can be generated, the normal gradation of carbon content from surface to point of deepest penetration occurs, but the surface always tends to have a carbon concentration of more than 1%. If parts were to be homogeneously carburized, the carbon content would have to be in this range, rather than 0.4, 0.6 or 0.8% as can be achieved by gas carburizing.

Pack carburizing is used to harden coined parts

Pack carburizing can be used advantageously to carburize iron powder parts, but is gradually being replaced by the cleaner, more economical gas carburizing methods. It is used primarily to harden parts after coining.

Advantages

Clean parts — Pack carburizing eliminates the problem of entrapment of foreign material in the pores of medium or low density compacts that occurs when liquid baths are used.

Selective hardening—Parts can be carburized, cooled in the pack at a rate slow enough to prevent hardening, and subsequently locally reheated and quenched to obtain hardness at specific points rather than over the entire part.

Disadvantages

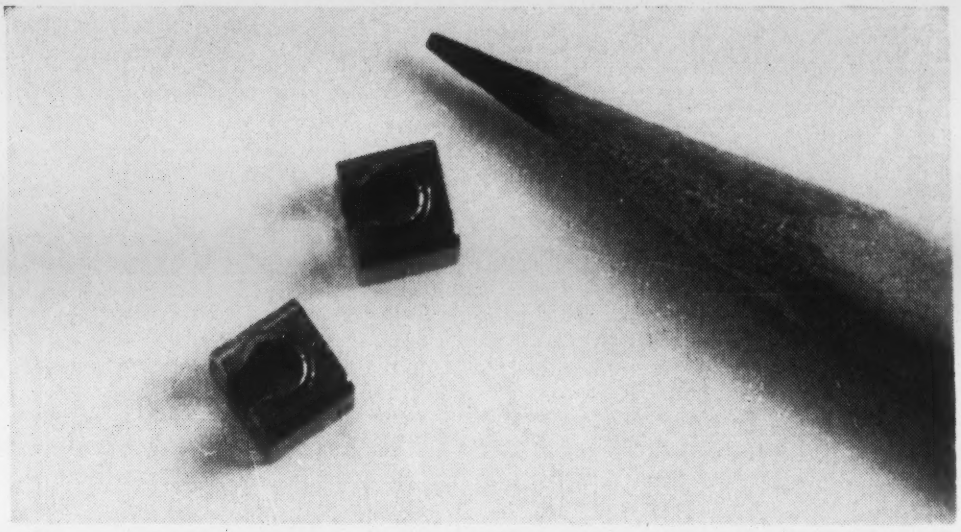
Copper barrier—Pack carburizing is not recommended for parts in which copper is used, either as an additive to the powder blend or as an infiltrant, because the copper acts as a barrier to carburizing. The materials used in this process do not react with copper to strip it from the iron particles, and spotty and uncontrollable penetration results.

Poor case depth control—When low and medium density parts are carburized by the pack method, they are carburized all the way through, because of their porosity. Some semblance of a case might be obtained on heavy sectioned, medium density parts by very close control of the carburizing cycle, but it would be practically impossible to control such a case within relatively close limits.

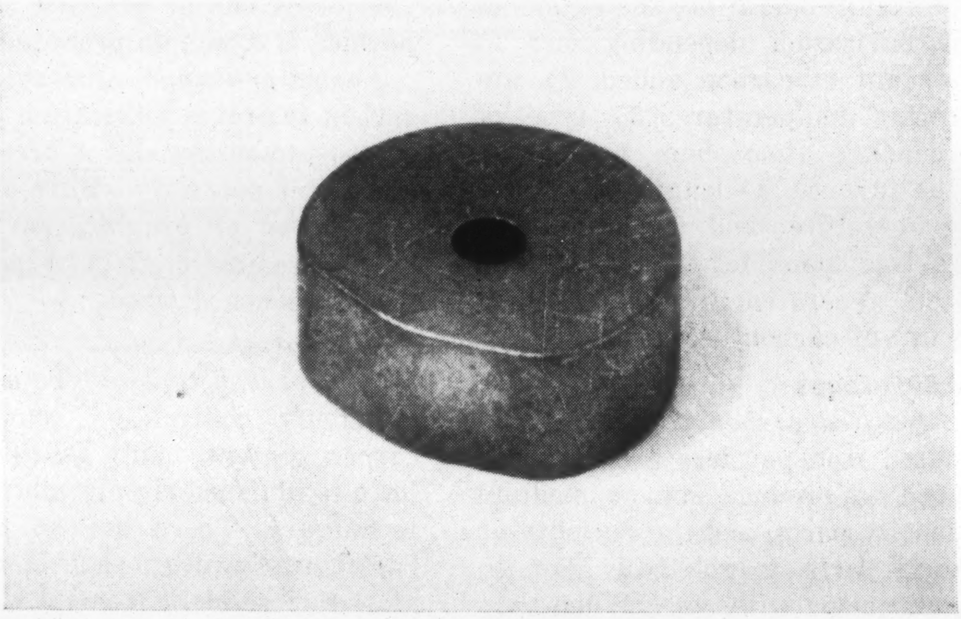
Limited carbon control—Carbon concentrations are normally in excess of 1.0% because the packing material is designed to develop and maintain such a potential. It is impossible to control the carbon potential at a lower level because of constant changes as the carburizing material burns out.

Decarburization—This is an extremely important factor. The carbon potential of the atmosphere generated by the carburizing material decreases as the temperature drops. As a result, parts made of high purity iron powders (e.g., electrolytic), which are pack carburized and allowed to cool in the pack, suffer severe surface decarburization. Investigation indicates that parts made of electrolytic iron tend to decarburize as fast as, if not faster than, they carburize, probably because electrolytic iron contains no impurities or alloying elements that tend to slow down decarburization.

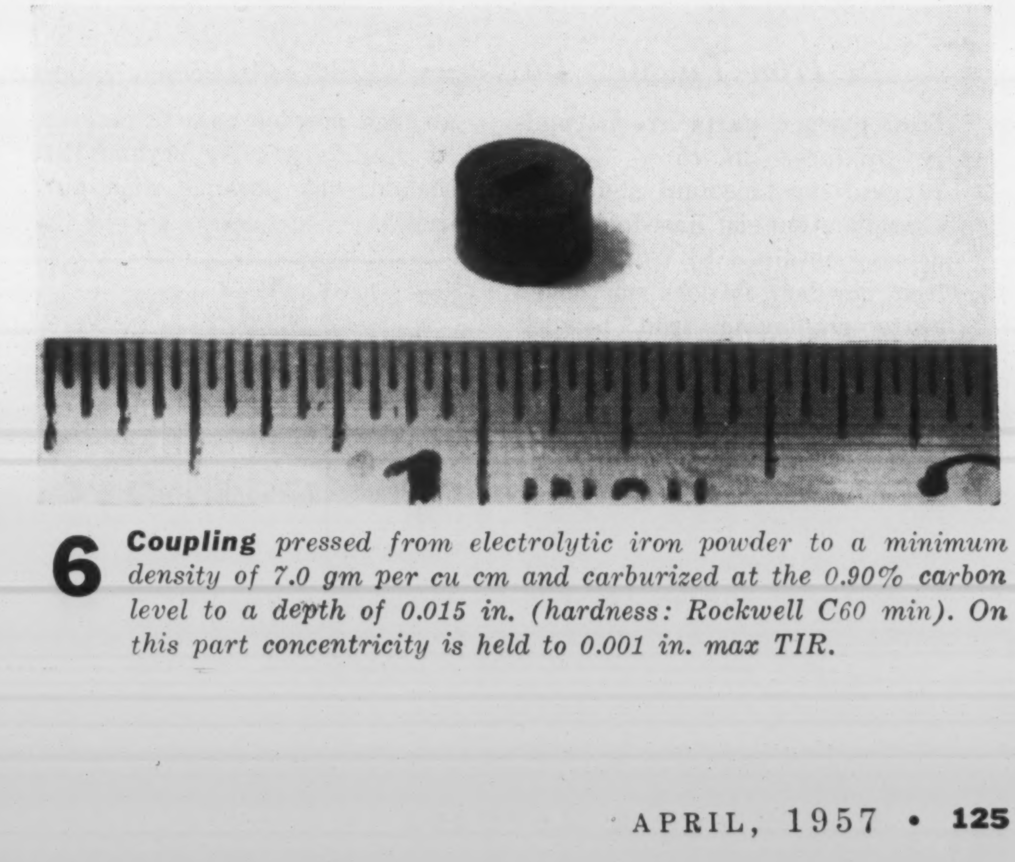
If the parts are quenched directly from the pack, most of this trouble can be eliminated, but exposure to air during transfer from pack to quench can produce slight surface decarburization. High density parts made from



4 **Cigarette lighter parts** *pressed from electrolytic iron powder to a minimum density of 7.0 gm per cu cm and carburized at the 0.90% carbon level to a case depth of approx 0.007 in. Full hard surface required for wear resistance.*



5 **Cam** *pressed from reduced iron powder to a minimum density of 6.9 gm per cu cm and carburized at the 0.070% carbon level. Case depth not specified because low density leads to uncontrollable penetration. Carbon level selected to obtain a surface combining wear resistance with toughness.*



6 **Coupling** *pressed from electrolytic iron powder to a minimum density of 7.0 gm per cu cm and carburized at the 0.90% carbon level to a depth of 0.015 in. (hardness: Rockwell C60 min). On this part concentricity is held to 0.001 in. max TIR.*

electrolytic iron can be quenched from the pack and a satisfactory surface with controlled case depth maintained.

Reduced iron powders that contain manganese, silicon, sulfur, phosphorus and possibly other metallic elements do not appear to be as susceptible to this reaction, although it is possible that decarburization could occur in such parts also.

Mechanical premixing gives more ductile parts

This method of adding carbon to iron powder parts is widely used in producing low and some medium density parts. Carbon is added, usually as finely divided graphite, directly to the iron powder blend. Parts are pressed to shape with this uniformly distributed carbon as an integral part of the compact. Alloying of the carbon takes place during the sintering operation, the extent of carburization depending on: 1) amount of carbon added, 2) sintering temperature, 3) type of reducing atmosphere present in the furnace, 4) length of time at temperature, and 5) amount of carbon monoxide and rate at which it is generated by the particular form of carbon used.

Advantages

Limited carbon content — Reduced iron powders are normally used to produce low or medium density parts, and the ductility of such parts is relatively low in comparison with steel. When they are carburized to a high carbon level, such parts have practically no ductility, even if they are not fully hardened. Mixing is usually employed when a combined carbon content of less than 1% is desired to modify the brittleness commonly associated with carburized and hardened parts of low or medium density. The lower combined carbon level results in an increase in strength together with retention of some ductility.

Low cost—Carburization occurs as part of the sintering cycle, thereby reducing the cost. Addition of carbon or graphite to the powder is a simple procedure.

Easier pressing—Admixture of carbon improves lubrication properties, promoting easier pressing.

Greater porosity — Burn-out of the carbon or graphite particles helps produce a highly porous product when desired.

Disadvantages

Poor carbon control—To obtain maximum control of combined carbon content, many fabricators have established rigidly controlled techniques. There are so many variables, however, that it is almost impossible to control within close limits the amount of carbon that combines with the iron. Slight variations in the major control factors of sintering temperature and time, atmosphere composition, and type and amount of carbon added to the powder blend have pronounced effects upon combined carbon content.

Coining difficult — Combination of carbon with the iron in the sintering operation produces a part that is hard and tough, similar to a high carbon steel. It is exceedingly difficult to coin such a part to any appreciable extent. Therefore, it is normally advisable to use this process for parts that do not require coining to control dimensions or increase density.

Residual carbon — Depending upon the amount of carbon added and the sintering conditions, some uncombined or unburnt carbon may be present in parts carburized after premixing. Residual carbon may or may not be a disadvantage. If lubricating properties are desired, the presence of free carbon or graphite may be decidedly advantageous. If strength is of prime importance, the presence of these particles is a disadvantage, as they tend to create planes or areas of weakness. The presence of additional voids created by carbon burn-out may also be a disadvantage when porosity is not a requirement.

Infiltration difficult—Parts that are to be subsequently infiltrated with copper to develop additional strength may pose a problem if they have been carburized after premixing. It is well known from copper brazing work that copper will not adhere as satisfactorily to steel having appreciable carbon content as it will to low carbon steel. Similarly, in high carbon iron powder parts infiltrated with copper it is possible that the copper actually acts only as a filler material, and the additional strength normally resulting from alloying of copper and iron is not obtained.

Iron Powder Parts — Classification

Iron powder parts are normally produced in three density ranges: low, medium and high. Classification is based on the density obtained by using 100% iron powder; it does not cover parts employing iron powder mixed or infiltrated with copper. In iron-copper parts the higher specific gravity of copper leads to erroneous and confusing density figures, because the density depends on the relative weights of iron and copper present. Sufficient copper can be added to an iron powder base to increase its specific gravity beyond that theoretically possible with pure iron.

Class	Density, gm/cu cm		Porosity, %	
	Max	Min	Max	Min
Low Density	6.5	—	—	17.3
Med Density	7.2	6.5	17.3	8.5
High Density	7.65[a]	7.2	8.5	2.5

[a] Practical limit at present.

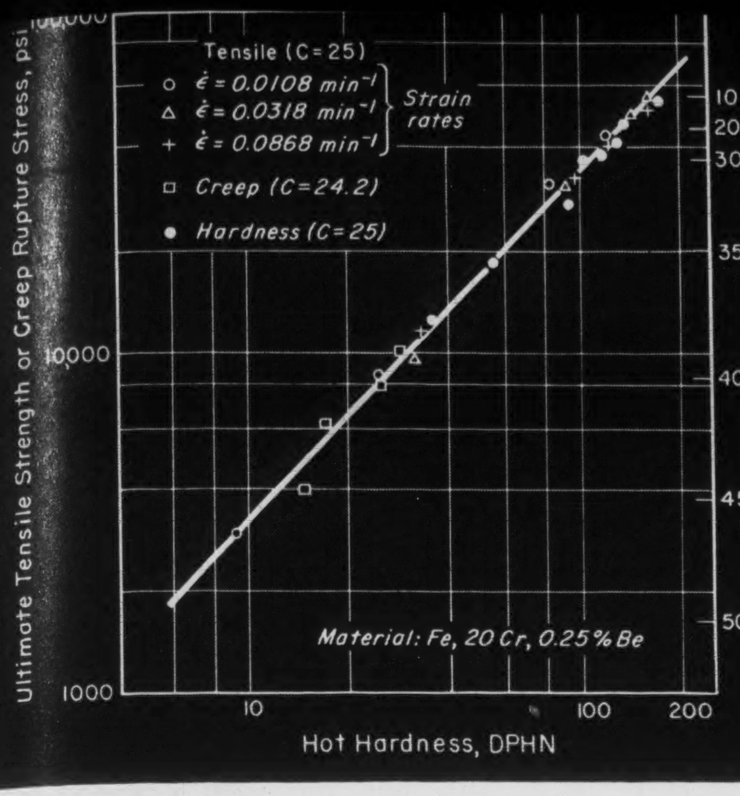


Fig 1—*Final result of Battelle research is a straight-line relationship between creep rupture stress and hardness. If either time or temperature is fixed, the other can be calculated from the right-hand scale.*

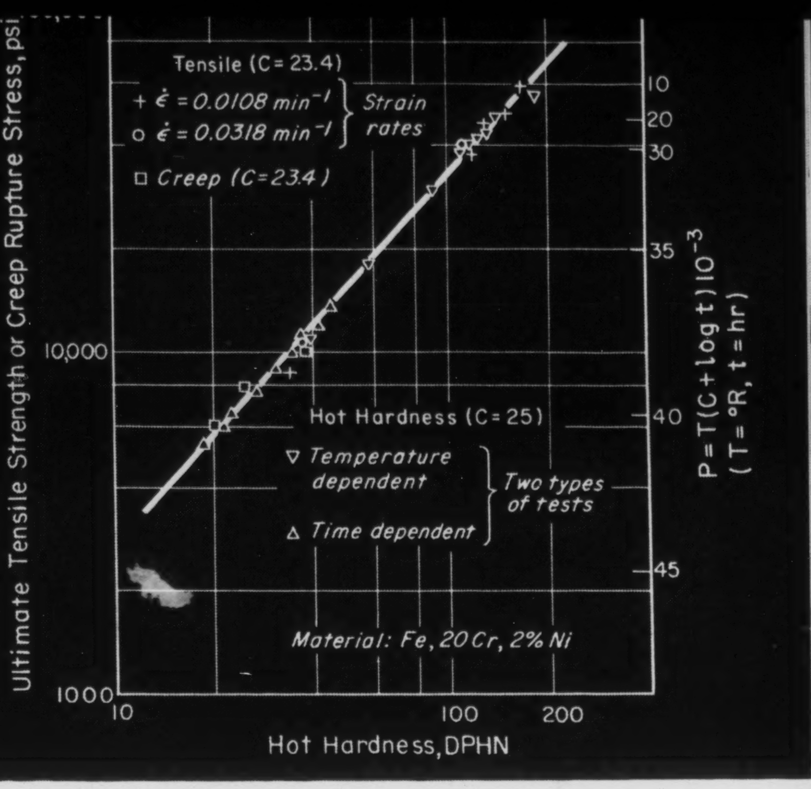


Fig 2—*Curve similar to Fig 1, but plotted for another alloy. On these graphs hardness, as well as tensile strength or creep rupture stress, can be read as a function of time and temperature.*

These curves show how you can determine . . .

Creep Properties from Short Time Tests

by Ervin E. Underwood,
Ass't. Division Consultant, Battelle Memorial Institute

The curve of Fig 1 (or Fig 2) represents a new correlation between hot hardness and strength properties. It can be read in two different ways:

1. If we ignore the right vertical axis entirely and the words "creep rupture stress" on the left vertical axis, what remains is simply a plot of ultimate tensile strength vs hot hardness.

2. If we ignore the words "ultimate tensile strength," we have a two-way plot: we can read creep rupture stress vs hot hardness, and we can also read a value of the parameter *P* for each rupture stress. This parameter introduces time and temperature, variables which are important in creep but not usually considered in determining ultimate strength by the tensile test. Using this parameter, we can assign a value either to time-to-rupture or to temperature, then calculate the other.

In other words, the meaning of the graph is this: if we know the hot hardness of this particular alloy, we can determine not only the ultimate tensile strength but also the creep rupture stress and the time-to-rupture at a given temperature.

How graph was obtained

The correlation curve of Fig 1 was obtained from standard tests yielding hot tensile strengths, creep rupture stresses and hot hardnesses. Typical data appear as in Fig 3 when plotted simply against the temperature. The stress to cause rupture falls on a vertical line at 1200 F because time is not considered. When these same data are replotted against the parameter *P*, they fall into two distinct curves (see Fig 4). Note that the tensile tests conducted with different strain rates now yield the same curve. Actually, for practical use, one strain rate would suffice.

In order to justify plotting hardness against *P*, the time dependency of the hardness data should be demonstrated. (In Fig 1 we can completely ignore the left vertical scale and read hot hardness vs *P*.) This dependency is shown in Fig 6. However, for most purposes, a normal hardness test with a fixed time is all that is needed. The two sets of hardness data plotted in Fig 5 show that the same hardness curve results whether time or temperature is the variable.

Now that tensile, creep and hardness have been plotted vs *P*, it is clear that the two curves are parallel and that the sharp break occurs at the same value of *P* for both the strength and the hardness curves. The flat portion of these curves corresponds to low temperature behavior; the steep portion is associated with a high temperature mechanism of deformation where recovery is operative. The sharp break corresponds to the equicohesive temperature, which may now be thought of more accurately as the equicohesive parameter point.

The final curves of Fig 1 and Fig 2 are obtained readily from those of Fig 4 and Fig 5 by plotting strength vs hardness at the same *P* values. Specifically, the horizontal and left vertical scales of Fig 1 are labeled first; then the right vertical or *P* scale is established by reading opposite any point on the strength curve of Fig 4 the corresponding value of *P*. The final curve itself can be determined from any two points on either curve (strength or hardness) of Fig 4.

This strength-hardness correlation was developed as a result of research at Battelle on high purity, single phase alloys. Research has since been extended to polyphase alloys. The similarity of curves of hardness and strength properties vs temperature permits us to predict the general validity of the correlation for the more complex alloys.

If this is true, a master curve can be determined for any alloy by running a few ultimate tensile strength tests, a hardness test, and two or three short creep tests. Then, within the limits of validity of the time-temperature parameter, the short hot hardness test can indicate creep rupture stress or tensile strength. These limits of validity are unknown at present, but for most applications this strength-hardness correlation appears to have wide potentiality as it exists now.

The background

It is well known that a more or less direct proportionality exists between the tensile strength of a wide variety of steels and the room temperature Brinell hardness. With the current interest in high temperature service, relationships have been sought for evaluating behavior by correlations between mechanical properties, particularly to avoid expensive and lengthy creep tests.

A relationship between hot hardness and stress rupture life

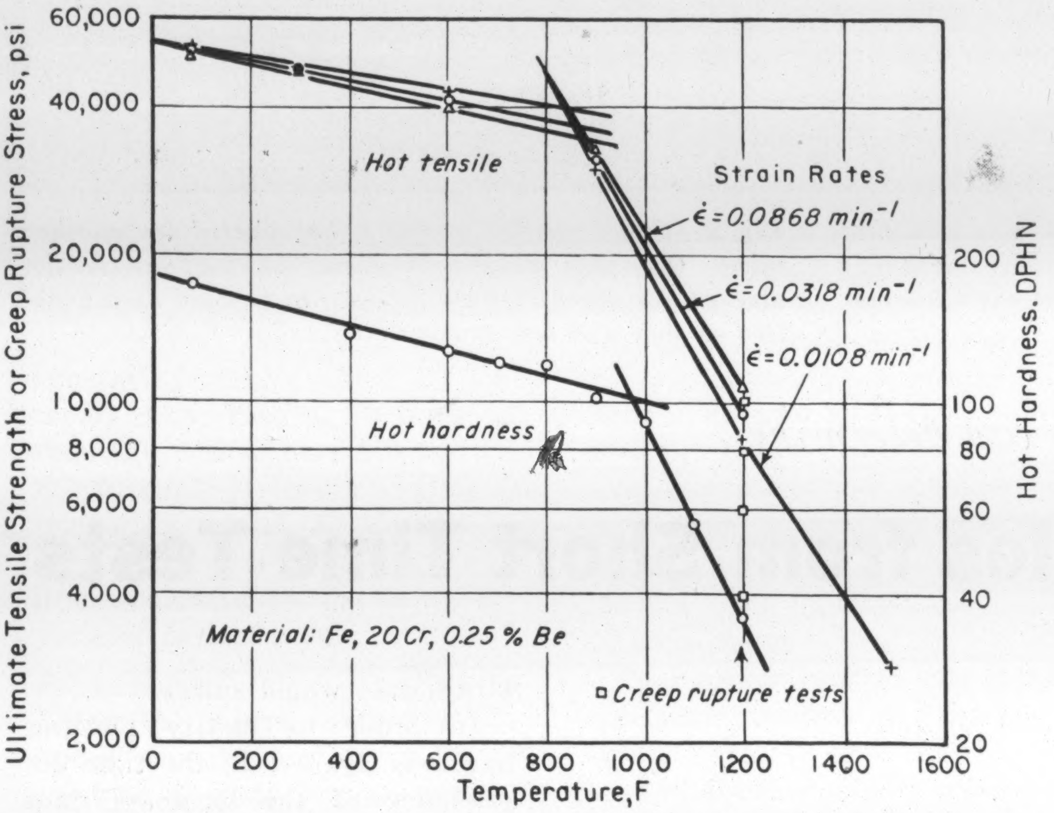


Fig 3—*Curves obtained by plotting test results against temperature, thereby neglecting time.*

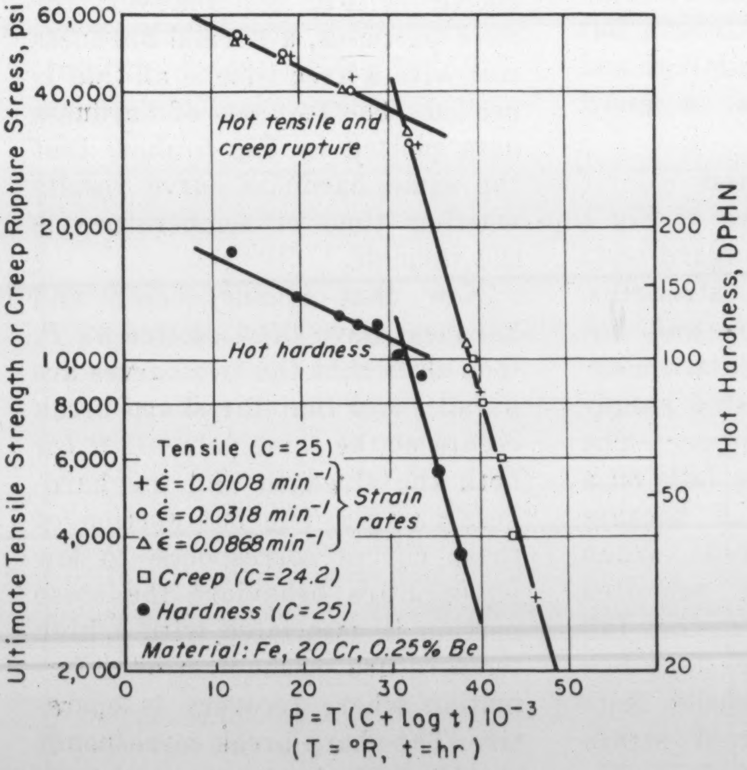


Fig 4—*Curves obtained by plotting test results vs a parameter involving time and temperature.*

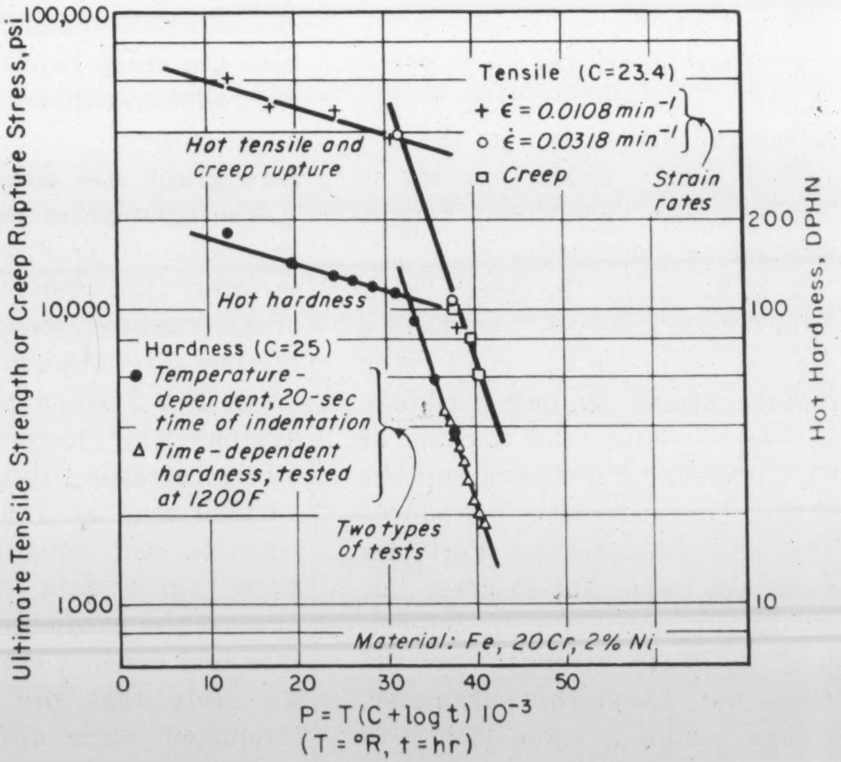


Fig 5—*Test results for second material with time-temperature dependence of hardness made explicit.*

was advanced by *Bens* (Fig 7). He measured the hardness at 1600 F of a wide variety of chromium-base alloys for which the rupture times at the same temperature were known. Although the scatter is considerable, the trend is evident. This relationship was one of the first to suggest a connection between the brief hot hardness test and the lengthy creep rupture test.

A similar attempt to correlate hot hardness with creep rupture stress was made by Smith and co-workers (*Garofalo*) at the U.S. Steel Laboratory. They plotted hot hardness vs stress to cause rupture in a certain time (Fig 8). They not only tested a wide range of steels, but also covered a range of temperatures. It can be seen that if the time factor were accounted for in some way, it would not be necessary to have a curve for each time. Also, it may be significant that the short time correlation appears to have the least scatter.

Smith and co-workers also demonstrated a direct-proportion relationship between hot hardness and hot tensile strength for a variety of steels over a range of temperatures. The results compare favorably with the known relationship between room temperature hardness and tensile strength.

An effort was made to bring time into the picture in such a way as to account for the interacting effects of time of test and temperature of test. In 1952, *Larson* and Miller applied the time - temperature parameter of Jaffe and *Hollomon* to creep rupture data. In one form this parameter can be expressed as: $P = T(C + \log t)$. T is absolute temperature (°R) and t is time to rupture (hr). C is a constant which Larson and Miller took to be about 20, but which varies according to the material being tested. They gave a rather complicated method for determining the value of C, but a simpler way is available. If we consider creep rupture tests, for example, it is apparent that the same parameter value should be obtained from tests at different temperatures—provided the stress is the same. A simple equation can be set up in which C is the only unknown. That is, $P = T_1(C + \log t_1) = T_2(C + \log t_2)$. So, if the two temperatures (T_1 and T_2) and the two rupture times (t_1 and t_2) are known, C can be calculated.

The curve of Fig 9 is a typical example of the correlations obtained by Larson and Miller using C= 20. Note that the hot tensile strengths conform to the master rupture curves.

This work of Larson and Miller was the starting point for the Battelle research described earlier.

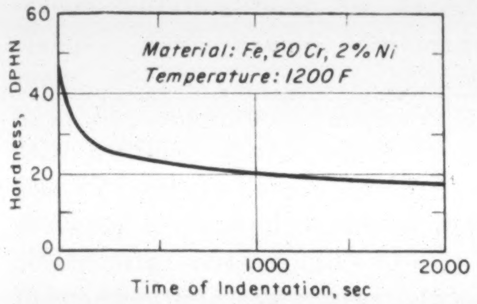


Fig 6—*Hardness dependence on time of indentation.*

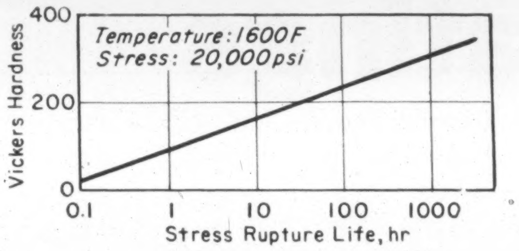


Fig 7—*Trend of stress rupture life in relation to hardness for chromium-base alloys.*

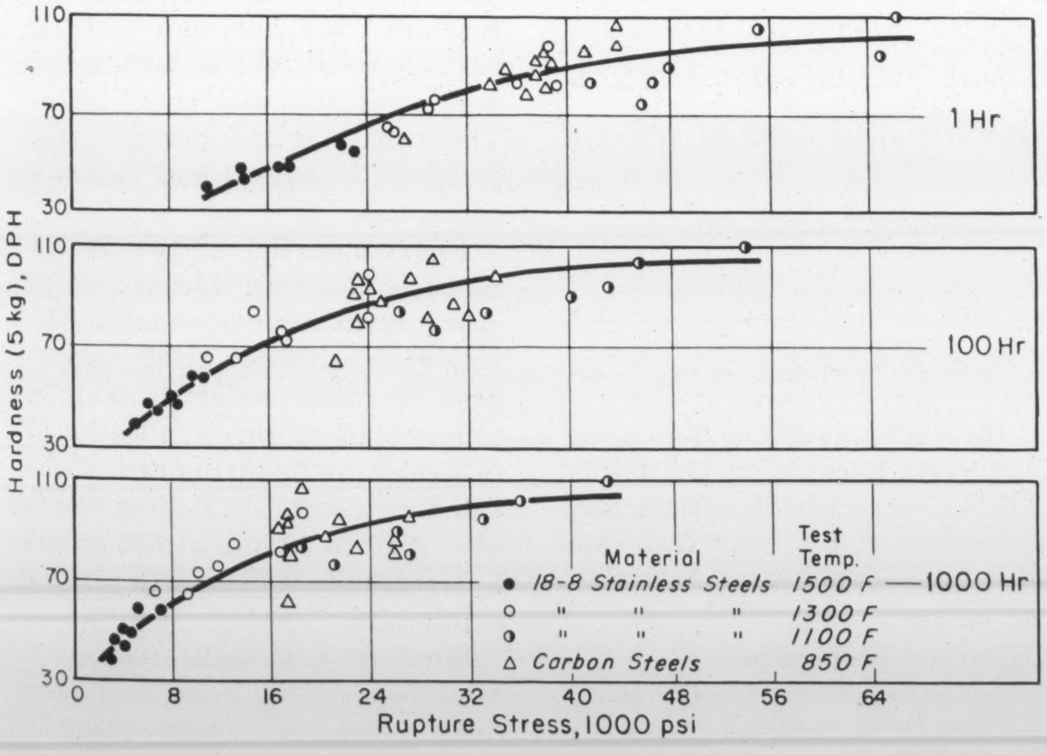


Fig 8—*Stress to cause rupture in stated time plotted vs hardness for stainless and carbon steels.*

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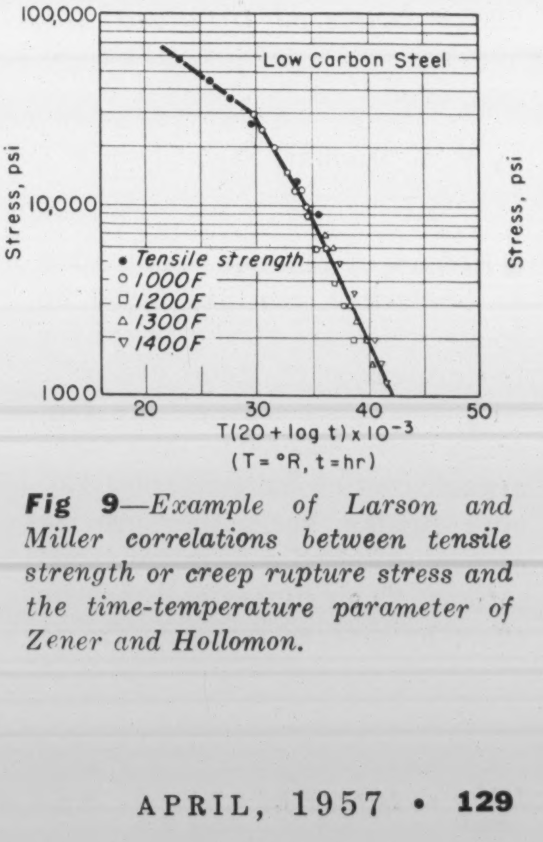


Fig 9—*Example of Larson and Miller correlations between tensile strength or creep rupture stress and the time-temperature parameter of Zener and Hollomon.*

Whirlpool-Seeger Corp.

Washing machine *surfaces are given epoxy coating to resist corrosive action of strong detergents.*

Roper Mfg. Co.

Water softener tanks *and heaters are given epoxy coatings to prevent corrosion by acids, organic chlorides and detergents.*

These photos show some current uses of . . .

Epoxy Coatings for Metal Products

These coatings are noted for their excellent adhesion, flexibility, toughness and chemical resistance. Here is detailed information on the properties and uses of the six main types of formulations.

by **R. E. Dunbar,** *Shell Chemical Corp.*

■ Because of a unique combination of properties, coatings based on epoxy resins are ideally suited for the protection of metal products. Although epoxy coatings are generally more expensive than other organic coating materials on a gallon-for-gallon basis, they provide economical service in many applications. Their higher cost may be offset by savings resulting from: 1) their adaptability to high speed production methods, 2) the ability of thin films to provide satisfactory protection, and 3) the fact that less costly structural materials can be used.

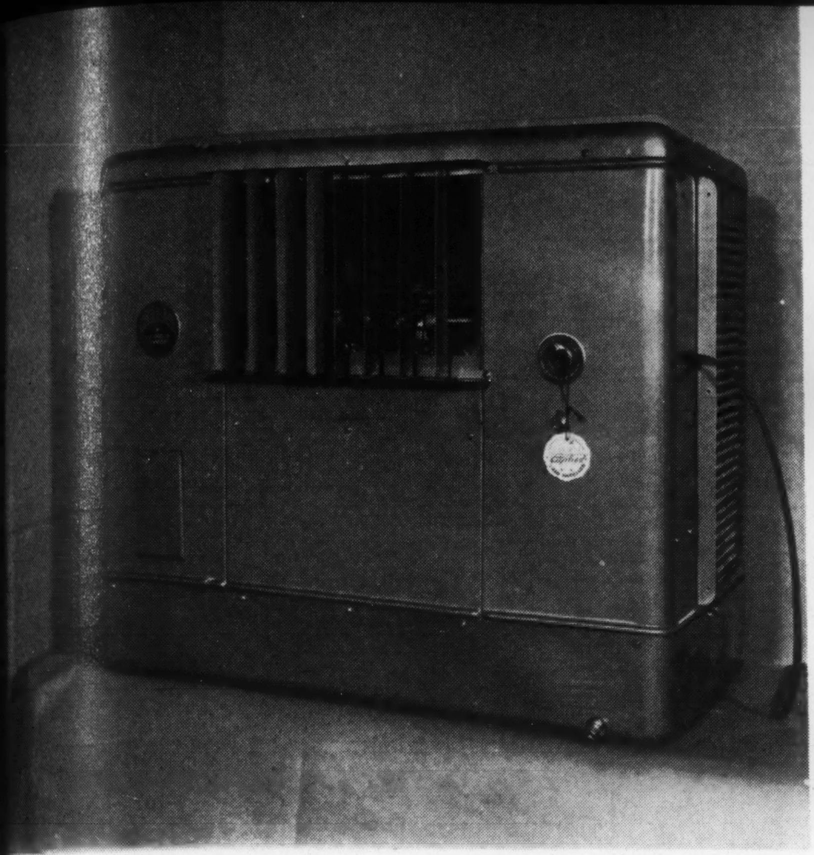
Types and properties

For satisfactory utility, epoxy resins must be modified chemically or blended with catalysts, curing agents or other resins. Epoxy resin finishes of commercial significance can be divided into six general classes of modification: epoxy-phenolics, epoxy-ureas, epoxy-amines, epoxy-polyamides, epoxy resin esters (unmodified), and epoxy resin esters modified with melamine or urea resins. Typical vehicle compositions are shown in Table 1. Comparative information on film properties and methods of application is listed in Tables 2 and 3.

Epoxy-phenolic baking coatings combine outstanding toughness, flexibility and adhesion with the best chemical and solvent resistance obtainable with epoxy resins. These coatings also possess excellent heat resistance and electrical properties.

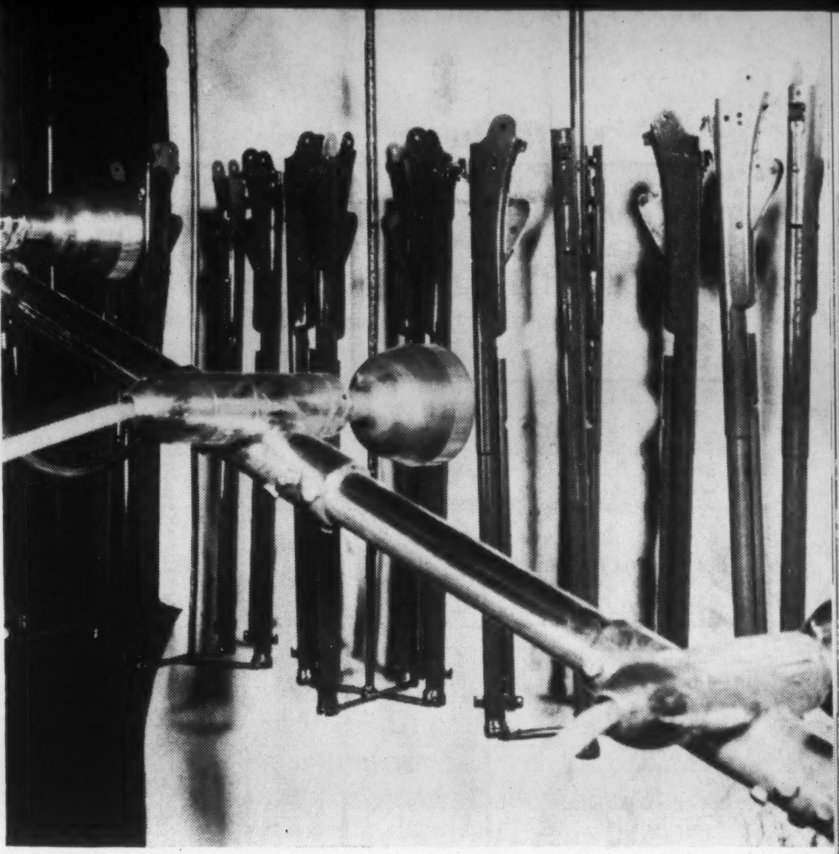
Epoxy-phenolic vehicles are essentially solution blends of an epoxy resin with a suitable phenolic resin, although small percentages of other materials may be employed to improve application or to accelerate the curing rate at elevated temperatures. Baking schedules of 20 to 30 min at 350 to 450 F are usually sufficient to provide a full cure.

Since most phenolic resins exhibit poor initial color and poor color retention, epoxy - phenolic combinations can only be used where the color of the coating is



National Engineering Co.

Air cooler *is given one coat of a tan metallic epoxy finish for decorative appeal and corrosion resistance.*



Daisy Mfg. Co.

Air rifle parts *coated with blue epoxy baking enamel resist impact, wear and corrosion.*

of little importance. Typical applications are can, drum, tank and pipe linings; wire coatings and impregnating varnishes.

Epoxy-urea baking coatings possess physical and chemical resistance properties that approach those of the epoxy-phenolics. They also have the advantage of good initial color and color retention in clear and white finishes.

Certain clear epoxy-urea coatings can be cured by baking for 20 min at temperatures as low as 300 F. Pigmented coatings usually require somewhat higher temperatures.

Typical applications of epoxy-urea coatings are: can linings; appliance primers; clear coatings for brass hardware, costume jewelry and vacuum metallized plastics; and coatings for hospital and laboratory furniture.

Epoxy-amine (amine-cured) coatings are unique in that films cured at room temperature exhibit a degree of chemical and solvent resistance associated normally only with baked coatings. Chemical resistance does not approach that of the phenolic and urea resin modifications, but the amine modifications have excellent chemical and solvent resistance when compared to other air dried coatings.

TABLE 1—TYPICAL COMPOSITIONS OF EPOXY RESIN FINISHES

Solids, % by wt		Solvents, % by wt[a]		Solids, % by wt		Solvents, % by wt[a]	
Epoxy-Phenolic				Epoxy-Polyamide			
Epon 1007[b]	73.1	MEK (methylethyl ketone)	15.0	Epon 1001	66.7	MIBK	33.3
Methylon 75108[c]	24.4	Neosol solvent[e]	25.0	Versamid 115[k]	30.0	"Cellosolve"	33.3
SR-82[d]	1.0	Pine oil	10.0	Beetle 216-8	3.3	Xylene	33.4
Phosphoric acid	1.5	Toluene	50.0				
Epoxy-Urea				Epoxy Resin Ester (unmodified)			
Epon 1007	70.0	MEK	15.0	Epon 1004[b]	60.0	Xylene	
Beckamine P-138[g]	30.0	Neosol	25.0	"9-11" acids[m]	40.0		
		Pine oil	10.0				
		Toluene	50.0				
Epoxy-Amine				Melamine-Modified Epoxy Resin Ester			
Epon 1001[b]	91.5	MIBK (methylisobutenyl ketone)	33.0	Epoxy resin ester	70.0	Xylene	
Beetle 216-8[h]	2.9	"Cellosolve"[j]	33.0	Melmac 245-8[n]	30.0		
Diethylene triamine (added shortly prior to use)	5.6	Xylene	34.0				

[a] Does not include solvents introduced by raw materials.
[b] Epoxy resin—Shell Chemical Corp.
[c] Phenolic resin—General Electric Co.
[d] Silicone resin—General Electric Co.
[e] Shell Chemical Corp.
[f] For spraying, formulation is reduced to application viscosity with equal parts by weight of diacetone alcohol and xylene.
[g] Urea resin—Reichold Chemicals, Inc.
[h] Urea resin—American Cyanamid Co.
[j] Carbide and Carbon Chemicals Co.
[k] Polyamide resin—General Mills, Inc. Packaged separately from the epoxy resin and mixed shortly prior to use.
[m] Dehydrated castor oil fatty acids—Baker Chemical Corp.
[n] Melamine resin—American Cyanamid Co.

TABLE 2—FILM PROPERTIES OF

Type of Finish	Appearance				Mechanical Properties					
	Color	Color Retention	Gloss	Gloss Retention on Exterior Exposure	Hardness	Adhesion	Flexibility, Impact Resistance	Abrasion Resistance	Cold Water Resistance	Hot Water Resistance
Epoxy-Phenolic (baked)	P-F	F	G	P[b]	E	E+	E	E+	E	E
Epoxy-Urea (baked)	G	G	G	P[b]	E	E+	E	E+	E	E
Epoxy-Amine (air dried)	E	F-G	E	P[b]	G-E	G-E	E initially; embrittles on aging	E	G	F
Epoxy-Polyamide (air dried)	F-G	F-G	E	P[b]	G-E	G-E	E initially; embrittles on aging	E	G	F
Epoxy Resin Ester (unmodified, baked)	G-E	G	G-E	P[b]	G-E	E+	E initially; embrittles slowly on aging	G-E	G	F
Melamine-Modified Epoxy Resin Ester (baked)	G-E	G	G	P[b]	E	E	G-E; may embrittle slowly on aging	E	E	F-G

[a] E+ = generally superior to other organic finishes; E = excellent, but not necessarily the optimum obtainable with other organic finishes; G = good; F = fair; P = poor.

[b] Loss in gloss is due to early chalking; it does not detract from metal protection.

[c] Aside from gloss retention.

Since the curing reaction between amines and epoxy resins takes place at room temperature, the amine curing agent must be packaged separately from the base formulation containing the epoxy resin. The usable life of mixed formulations varies from several hours to several days, depending on ambient temperature and formulation variables. At room temperature, epoxy-amine coatings reach a high degree of cure within 24 hr but require up to seven days to approach maximum chemical and solvent resistance. Curing rates can be greatly accelerated by force drying or baking; a full cure can be obtained by baking for only 10 min at 250 F.

Although epoxy-amine coatings are most widely used in industrial maintenance applications, they are also useful on original equipment when baking is inconvenient or not feasible. Representative applications are linings for transmission pipelines, and coatings for machinery, process equipment and structural steel in chemical plants.

Epoxy-polyamide coatings contain polyamide resins that have amino reactive groups. For this reason, the handling properties, curing requirements and film properties of these coatings closely parallel those of epoxy-amine coatings. In general, the polyamide resin modifications show somewhat poorer solvent resistance and initial color than the amine modifications, but slightly better flexibility on aging.

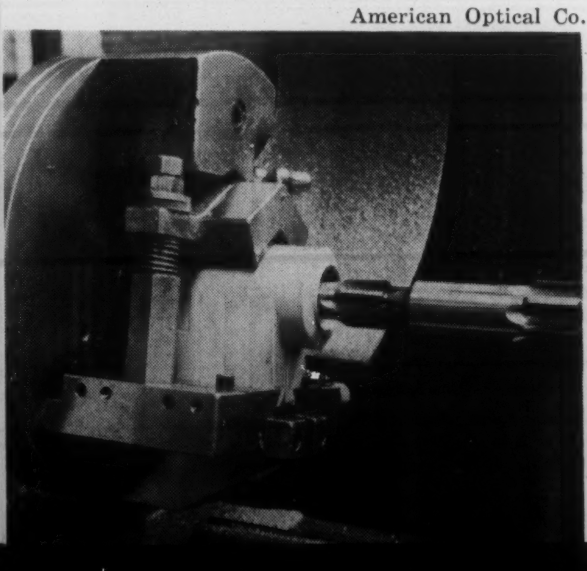
Unmodified epoxy resin ester coatings combine excellent mechanical properties with relatively low cost. As a result, they are the most popular of the epoxy coatings and are widely used as overprint varnishes; as primers for automobiles, appliances and other equipment; and as original and maintenance coatings for structural steel.

Epoxy resin esters closely parallel alkyd resins in vehicle properties and curing requirements. However, the epoxy resin ester coatings generally exhibit better flexibility, adhesion, toughness and chemical resistance than the alkyds, but are slightly more expensive and do not have quite as good color retention.

Coatings based on short-oil length epoxy resin esters are normally used in production line finishing applications. These coatings are ordinarily cured by baking for 10 to 30 min at 300 to 350 F, although they can be cured at room temperature with the addition of conventional driers.

Scuff-proof *epoxy coating applied to scientific and optical instruments prior to machining is not damaged by chucking, boring, reaming and threading operations.*

American Optical Co.



EPOXY RESIN FINISHES[a]

Chemical Properties			Environmental Properties	
Solvent Resistance	Alkali Resistance	Acid Resistance	Heat Resistance	Exterior Durability[c]
E to aliphatics, aromatics and alcohols; G-E to ketones and esters	E+	E to dilute acids; F-G to conc nonoxidizing acids; P to conc oxidizing acids	E	E pigmented, G clear
E to aliphatics, aromatics and alcohols; G to ketones and esters	E	G-E to dilute acids; F to conc nonoxidizing acids; P to conc oxidizing acids	E	E pigmented, G clear
E to aliphatics and aromatics; F-G to alcohols, ketones and esters	G	F-G to dilute acids; P to conc acids	G	E pigmented, F clear
E to aliphatics and aromatics; F-G to alcohols, ketones and esters	G	F-G to dilute acids; P to conc acids	G	E pigmented, F clear
F to aliphatics; P to aromatics, alcohols, ketones and esters	F-G	P	F	E pigmented, G clear
G to aliphatics; F to aromatics; P to alcohols, ketones and esters	G	P-F to dilute acids; P to conc acids	G	E pigmented, G clear

Coatings based on the longer oil length esters cure at room temperature and are generally used on equipment that cannot be baked conveniently.

Modified epoxy resin ester baking coatings, based on solution blends of drying type esters with melamine or urea resins, provide films with better hardness and chemical resistance than the unmodified esters, but with somewhat poorer flexibility and impact resistance. Slightly better initial color and color retention can be obtained when esters made from nondrying acids are used instead of the drying types. Baking schedules of 20 to 30 min at 300 to 350 F are generally required for all of the epoxy ester finishes.

Clear coatings

For copper, brass and silver—Because of the constant handling experienced by hardware, costume jewelry and small appliances, clear coatings for these products must possess excellent adhesion and resistance to abrasion and perspiration. The coatings must also remain free from yellowing for long time periods. Epoxy-urea coating systems exhibit an outstanding combination of these properties. For most copper, brass and silver products satisfactory protection is provided by a single coat of less than 1 mil.

Where baking is impractical because of the size of the part, excellent results can be obtained with a single coat of an epoxy-amine finish which cures at room temperature.

TABLE 3—HOW AND WHERE EPOXY FINISHES ARE APPLIED

Type of Finish	Method of Application	Approximate Solids Content at Spray Viscosity, %		Spray Coat Film Thickness, mils	Typical Curing Schedules	Typical End Uses
		Clear	Pigmented White[a]			
Epoxy-Phenolic	Spray, roller, dip, flow	30	45	0.7-1.1	20 min at 375 F	Can, drum, pipe and tank linings; wire coatings and impregnating varnishes
Epoxy-Urea	Spray, roller, dip, flow	30	45	0.7-1.1	20 min at 300 F[b] 20 min at 385 F[c]	Can linings; appliance primers; clear coatings for brass hardware, jewelry and vacuum metallized plastics; foil coatings; and coatings for laboratory and hospital furniture
Epoxy-Amine	Spray, brush	40	55	1.0-2.0	Air dry (55 F min) or bake (10 min at 250 F)	Linings for transmission pipelines; coatings for machinery, process equipment and structural steel in chemical plants
Epoxy-Polyamide	Spray, brush	40	55	1.0-2.0	Air dry (55 F min) or bake (10 min at 250 F)	Generally same uses as epoxy-amine finishes
Epoxy Resin Ester (unmodified)	Spray, roller, dip, flow, brush	30-35	50	0.7-1.1	Air dry or bake (20 min at 325 F)	Overprint varnishes; primers for autos, appliances and other equipment; foil coatings; original and maintenance finishes for structural steel
Melamine-Modified Epoxy Resin Ester	Spray, roller, dip, flow	30-35	50	0.7-1.1	30 min at 300 F	Generally same uses as unmodified epoxy resin ester finishes

[a] Titanium dioxide, pigment: binder = 1:1. [b] Clear finish. [c] White finish.

For aluminum—Epoxy resin ester coatings exhibit excellent adhesion, flexibility and abrasion resistance over aluminum. Because of their relatively low cost they are generally preferred for use on foil and ornamental vacuum metallized surfaces.

Epoxy-urea coatings, however, provide better protection against corrosion and chemicals over aluminum and are required in some applications. An example is the use of a specially formulated epoxy-urea coating on vacuum metallized flash reflectors. Here the coatings must provide complete protection against corrosion and must be able to withstand rough handling.

For tin plate—Because of their combination of toughness, flexibility and chemical resistance, epoxy resin coatings are well adapted to coating sheet metal prior to fabrication. Typical of the large volume industrial applications in this category is the use of a clear epoxy-phenolic prime coat in lining beverage cans. The coating remains undamaged during welding of the side seams.

Epoxy-urea and epoxy-phenolic coatings are also gaining increased acceptance as linings for lard, meat and other food containers. These coatings have demonstrated superior performance in food packaging, but their growth has been slowed somewhat by the time consuming tests required for government approval.

Overprint varnishes

Epoxy resin esters make ideal overprint varnishes. They are usually specified because the strong solvents required in other epoxy systems dissolve, lift or cause bleeding of lithographic inks.

Epoxy resin esters are essentially colorless in thin films and exhibit superior toughness and abrasion resistance when compared to conventional overprint varnishes. Because of their excellent flexibility and adhesion, they can be applied to lithographed sheet metal prior to fabrication. Application of epoxy overprint varnishes on bottlecaps, can closures, trays and similar products is one of the largest end uses for epoxy coatings.

Pigmented coatings

For steel—Aside from color, pigments in epoxy coatings are employed principally to increase film build-up and exterior durability, and to improve resistance to moisture, chemicals and abrasion. Because of the outstanding protection provided by epoxy primers, and because of certain decorative limitations of epoxy enamels, the best over-all performance on steel surfaces is frequently obtained by using an epoxy primer under an alkyd, lacquer or acrylic topcoat.

Although the color retention of white epoxy enamels is adequate for many products, alkyd topcoats are slightly superior in this respect and are generally preferred for appliances. Good corrosion and abrasion resistance for washing machines is obtained by using a melamine-modified epoxy resin ester primer or an epoxy-urea primer and a conventional alkyd resin topcoat. An epoxy primer alone is usually sufficient to protect interior surfaces.

Last of a Series

This is the last in a series of five monthly articles on synthetic resin-base coatings for metal products. Previous articles were devoted to acrylic (Dec '56), phenolic (Jan '57), silicone (Feb '57) and vinyl (Mar '57) coatings.

For products such as office furniture and kitchen cabinets, where mechanical durability is required, melamine-modified epoxy resin ester finishes are the most economical. For hospital and laboratory equipment, where chemical or solvent resistance is also required, epoxy-urea finishes are preferred. In these applications, surface preparation is generally limited to a conventional acid pretreatment.

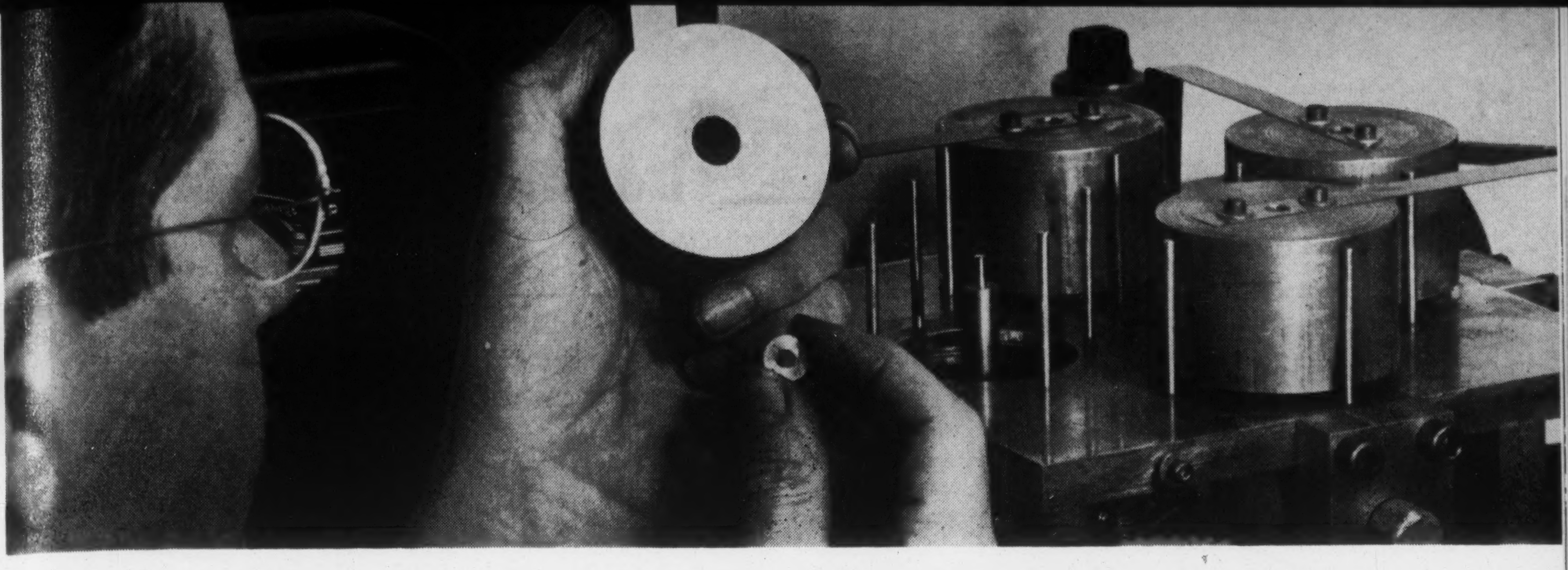
Epoxy resin coatings also provide excellent durability and corrosion protection to surfaces subjected to outdoor exposure. Although epoxy enamels tend to lose gloss by chalking at an earlier stage than alkyd enamels, loss in film thickness is negligible during extended exposure. If a loss in gloss can be tolerated, a coating system using both an epoxy primer and an epoxy enamel provides excellent outdoor protection.

Where gloss retention is required outdoors, the use of an epoxy resin ester primer under an alkyd, lacquer or acrylic topcoat is finding increased acceptance. Coating systems of this type are widely used for automotive finishing and the primer is applied in a single, 1-mil (dry) coat. For products such as outdoor furniture, less than 0.5 mil of a melamine-modified epoxy resin ester primer is usually required. (This thickness is about half that normally used with alkyd resin primers.) The epoxy resin primers provide good resistance to chipping and corrosion and, because of their excellent adhesion, they inhibit corrosion creepage if film damage occurs.

Multiple coats of an epoxy-phenolic system, applied to a sandblasted surface, are widely used to protect steel drums, tanks and pipe in contact with chemicals, hot water and strong solvents. Because of their excellent mechanical properties, these coatings are often preferred over coatings that appear to be superior in straight immersion tests.

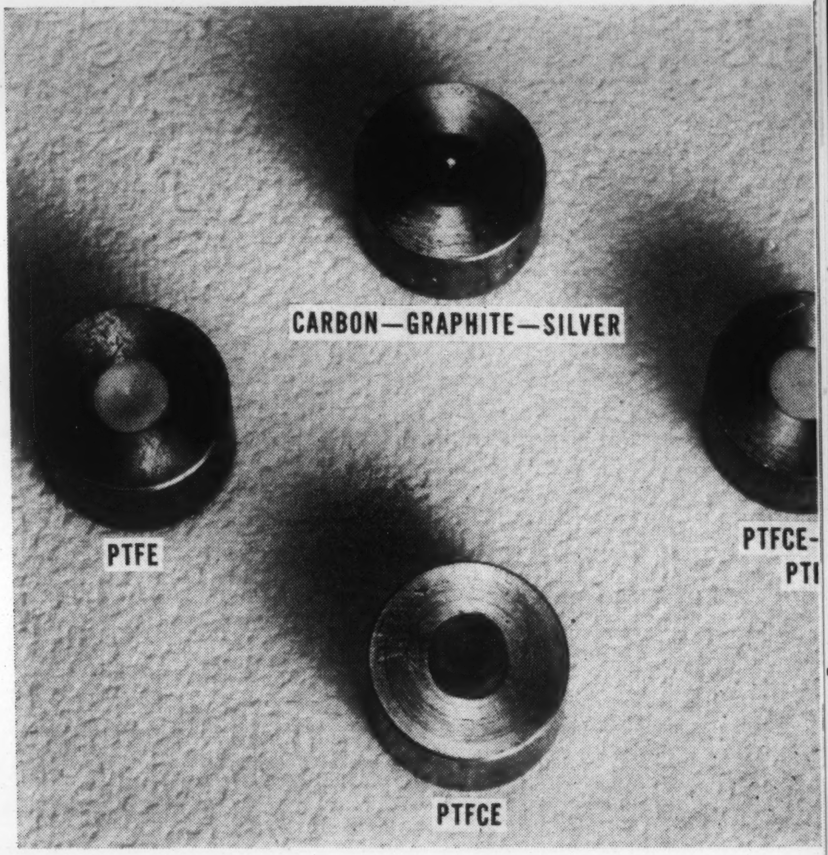
Where a high degree of corrosion protection is required, 6 to 7 coats with a total thickness of 5 to 7 mils are frequently specified. A partial bake is given to each coat after application and a final bake is given to the topcoat to complete the cure.

For aluminum — Aside from tinted transparent finishes, the major use for epoxy resin primers and enamels over aluminum has been for aircraft. Epoxy-amine coatings are used primarily because they can be cured at room temperature and because of their excellent resistance to the solvent action of brake and de-icing fluids.



After 60 days in wear tester (above) these specimens show wide variations — a good reason for careful evaluation in selecting

Materials for Small, Oil-Free Bearings



Here are data on wear rates and friction coefficients of many combinations of metallic and nonmetallic materials.

by Hobart S. White,
National Bureau of Standards

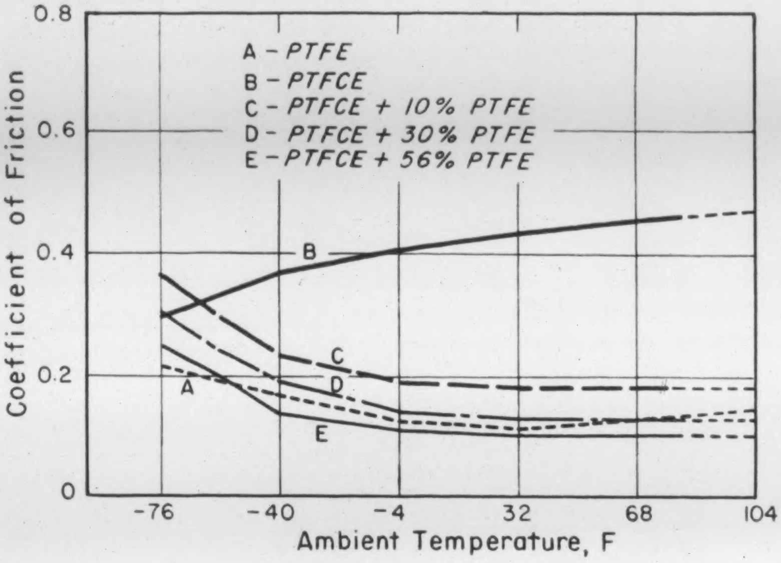
■ It is a well known fact that the increased viscosity and congealing of oils at subzero temperatures produces excessive friction and seriously interferes with the performance of lubricated bearings used in small instruments. In some devices this added friction can be overcome by providing extra driving power. For many instruments, however, this solution is not feasible and the designer must seek out a satisfactory low temperature lubricant or else switch to an oil-free bearing with low friction properties.

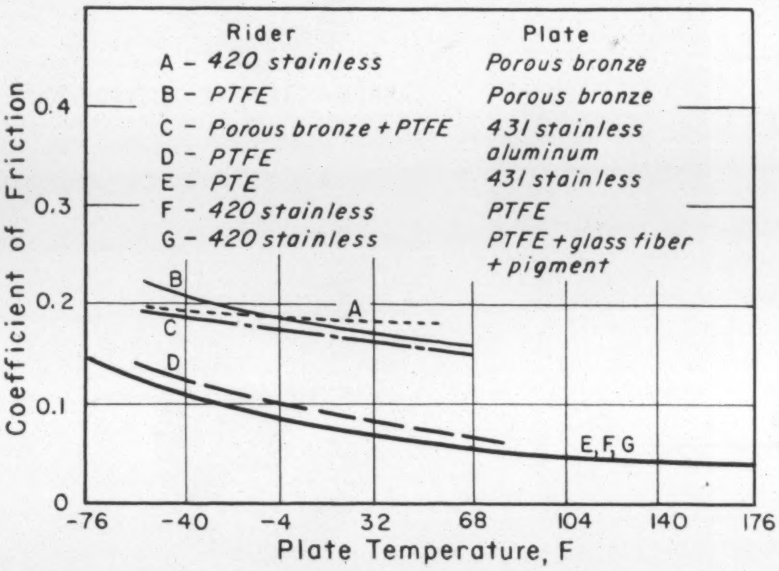
Recently there has been developed a number of oil-free bearing materials that provide a low coefficient of friction and low wear over a wide temperature range. These materials also eliminate the need for periodic cleaning and oiling during storage and service.

As shown in the accompanying tables and graphs, friction and wear characteristics have been determined for a variety of oil-free bearing materials. In general, these materials can be classified into five main groups as follows: 1) plastics such as polytetrafluoroethylene (PTFE), polytrifluorochloroethylene (PTFCE), nylon and high density polyethylene; 2) plastics with various fillers, such as graphite, molybdenum disulfide, glass fiber, dental silicate, silicon, titanium dioxide, silver, copper,

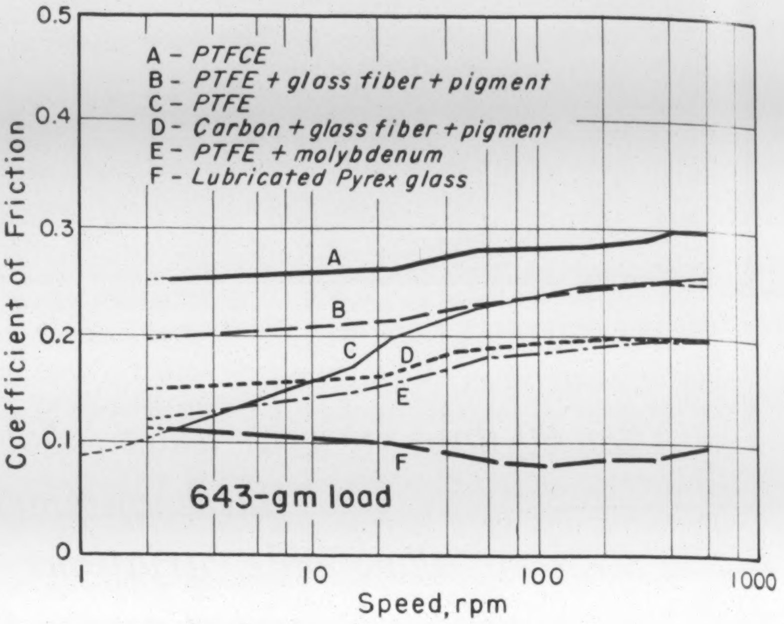
Coefficient of Friction of

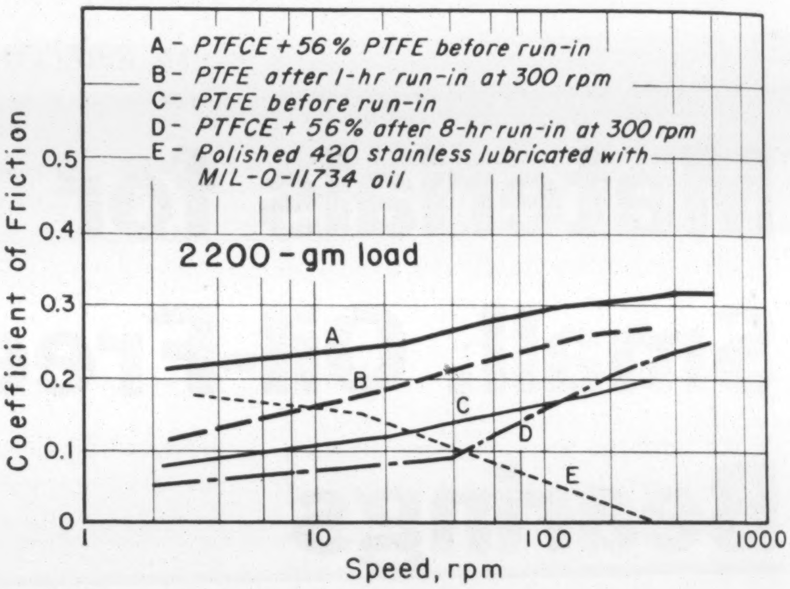
VS TEMPERATURE





VS SPEED





tungsten and molybdenum; 3) bronze impregnated with PTFE, graphite and molybdenum disulfide; 4) graphite and electrographitic carbon impregnated with silver and babbitt; and 5) various other materials such as stainless steel, anodized aluminum, brass, diamond, etc. Principal characteristics of these groups of bearing materials are summarized below.

Plastics

PTFE—Because of its tendency to wear, PTFE is not recommended as a bearing material for small instruments such as clocks and chronometers. The usefulness of this material is also limited by an increase in its coefficient of friction below —4 F. At very low surface speeds and low pressures its wear resistance may be adequate for special applications.

PTFCE—The high friction and wear rate of PTFCE at ordinary temperatures preclude its use as an oil-free bearing material in timepieces. The decrease in friction of this material at low temperatures, however, is a distinct advantage and may make it useful for special low speed applications.

PTFE and PTFCE Coatings—In journal bearings, a fused coating of PTFCE provides good wear resistance but has a relatively high coefficient of friction. A fused coating of PTFE provides lower friction, but at the expense of decreased wear resistance. Both of these coatings wear rapidly when used as thrust bearings. Because of the thickness of the coatings ordinarily used, and the difficulty in producing a uniform coating with a good bond on small parts, these coatings do not seem practical for journals or bearings less than 1/16 in. in dia. However, work at the Naval Research Laboratory indicates that PTFE coatings may be useful for some applications.

Nylon—Nylon has been used as a bearing material in a number of industrial applications (see "Teflon and Nylon Bearing Materials," M&M, Mar., '56, p. 100). How-

Various Bearing Materials

RUNNING AGAINST STEEL SHAFTS[a]

Shaft Material[b]	Coefficient of Friction at 3 Rpm after . . .					
	0 Hr	1 Hr	2 Hr	4 Hr	6 Hr	8 Hr
PTFE						
M	0.06	0.09	0.11	0.12	0.12	0.13
D2	0.10	0.20	0.23	—	—	—
D3	0.10	0.17	0.17	0.15	0.15	0.15
C40	0.06	0.07	0.08	0.10	0.11	0.11
440C	0.10	0.13	0.14	0.15	0.15	0.15
PTFE + 65% (31% by vol) Molybdenum Powder (0.5-5.0 μ)						
M	0.07	0.19	0.27	0.32	0.32	0.33
D2	0.08	0.12	0.15	0.20	0.23	0.25
D3	0.08	0.10	0.10	0.12	0.15	0.22
C40	0.03	0.09	0.09	0.06	0.06	0.07
440C	0.06	0.07	0.07	0.09	0.12	0.15
PTFCE + 56% PTFE (fused at 500 F)						
M	0.08	0.19	0.17	0.15	0.14	0.13
D2	0.16	0.19	0.18	0.15	0.13	0.13
D3	0.20	0.20	0.16	0.13	0.12	0.11
C40	0.04	0.10	0.11	0.13	0.14	0.13
440C	0.17	0.18	0.15	0.14	0.13	0.13
Carbon + Graphite + Silver						
M	0.24	0.29	0.33	0.36	0.36	0.34
D2	0.16	0.23	0.25	0.30	0.34	0.34
D3	0.20	0.27	0.28	0.29	0.30	0.30
C40	0.22	0.25	0.26	0.27	0.27	0.27
440C	0.20	0.24	0.24	0.25	0.25	0.26

[a] ¼-in. bearings, 2200-gm load, 77 F.

[b] M — Chromium-vanadium alloy machinery steel with small amounts of nickel and molybdenum, Rc 24. D2 — Air hardened, high chromium tool steel, Rc 55. D3 — Oil hardened, high chromium tool steel, Rc 60. C40 — 40 cobalt — 20 chromium — 15 nickel — 7 molybdenum — 2 manganese alloy, Rc 58.

RUNNING AGAINST 420 STAINLESS STEEL[a]

Material	Coefficient of Friction at . . .		
	3 Rpm (0.2 sfm)	15 Rpm (1.0 sfm)	300 Rpm (20 sfm)
Polytetrafluoroethylene (PTFE)	0.12	0.18	0.26
PTFE + 13% Glass Fiber (0.05μ avg dia)	0.22	0.23	0.25
PTFE + Glass Fiber + Pigment	0.20	0.21	0.26-0.32
PTFE + Glass Fiber + Molybdenum disulfide (MoS_2)	0.11	0.13	0.18
PTFE + Graphite	—	—	0.28
PTFE + Copper Powder	0.13	0.16	0.22
PTFE + 73% (40% by vol) Molybdenum Powder	0.13	0.15	0.20
PTFE + 70% (34% by vol) Mo + 6% Chromium Tetrahydrate	0.30	0.31	0.33
PTFE + MoS_2	0.13	0.18	0.28
PTFE + 90% (50% by vol) Tungsten Powder	0.18	0.20	0.22
PTFE + 28% (18% by vol) Titanium Dioxide (TiO_2)	0.23	0.23	0.27
PTFE + 18% TiO_2 + 4% Polymethylsiloxane	0.15	0.19	0.26
PTFE + 18% TiO_2 + 11% Chlorinated Biphenyl	0.16	0.18	0.23
PTFE + 80% (52% by vol) Tin (fused at 700 F, 10,000 psi)	0.15	0.17	0.20
PTFE + 70% (33% by vol) Silver Precipitated Flowers	0.27	0.26	0.23
Polytrifluorochloroethylene (PTFCE)	0.25-0.27	0.26-0.28	0.29-0.45
PTFCE + 56% PTFE (fused at 500 F)	0.22	0.22	0.26
PTFCE + 51% PTFE + 10% Glass Fiber (fused at 500 F, 13,000 psi)	0.26	0.26	0.26
PTFCE + 14% (27% by vol) PTFE + 64% (28% by vol) Mo	0.16	0.19	0.23
PTFCE + MoS_2	0.36	0.36	0.40
PTFCE + Graphite	0.16-0.25	0.18-0.26	0.24-0.29
PTFCE + 51% PTFE + 13% Chromium Tetrahydrate	0.20	0.22	0.25
Nylon, Molded	—	—	0.28-0.35
Nylon, Sintered and Machined	0.22	0.20	0.28-0.32
Nylon, Resintered after Machining	0.28	0.26	0.32-0.33
Carbon + Graphite + Silver	0.15	0.16	0.20-0.28
Electrographitic Carbon + Silver	0.28	0.28	0.27
Carbon + Graphite + Babbitt	0.21	0.22	0.23
Electrographitic Carbon + Babbitt	0.27	0.27	0.26
Silver Amalgam	0.13	0.13	0.12
Polished 420 Stainless Steel with MIL-G-7421 Grease	0.08	0.06	0.06
Polished 420 with MIL-O-11734 Oil	0.18	0.16	0.03
Polished 420 with Watch Oil	0.12	0.06	0.04
Anodized 6061 Aluminum with Watch Oil	0.13	0.06	0.05
Polished Sapphire (clean)	0.18	0.20	0.36
Polished Sapphire with Watch Oil	0.12	0.06	0.05
Polished Sapphire with Oil Wiped Off	0.13	0.14	0.21

[a] ¼-in. hardened shafts, room temperature, 643-gm load.

ever, it possesses a higher friction coefficient than a number of the other materials for small, oil-free bearings. Because of its relatively large variation in water content and change in size with temperature and humidity, the material cannot be recommended for precision bearings.

High density polyethylene—The coefficient of friction of this material is somewhat greater than that of PTFE, especially at low temperatures. Its rate of wear at 150 rpm, however, is less than that of the other unfilled plastics described above.

Plastics with fillers

PTFCE containing 10 to 60% PTFE as a filler is one of the most promising oil-free bearing materials developed. This material possesses some of the hardness of PTFCE and the frictional characteristics of PTFE, and it has much greater wear resistance than either of these plastics alone. Unfortunately, the fact that its frictional characteristics are similar to those of PTFE detracts from its usefulness at subzero temperatures. PTFCE containing graphite and molybdenum disulfide also exhibits a lower friction coefficient and greater wear resistance than

PTFCE alone, but these dry lubricant additives are not as effective as the PTFE filler.

PTFE bearings containing molybdenum metal powder (0.5 to 5 microns) as a filler have shown considerable promise. This mixture possesses good friction characteristics and exceptional wear resistance under certain conditions.

Preparations of PTFE containing glass fiber and pigment also have good wear and friction properties when used as oil-free bearings with a 0.25-in. bore. The relatively large size of some of the glass fibers and the large pockets of plastic in the mixture preclude its use for small bearings where the bore may be only a few mils in diameter. Additions of graphite, copper powder or molybdenum disulfide to PTFE also reduce wear in 0.25-in. bearings but, here again, formation of pockets in the plastic prevents use of the material in smaller sized bearings.

Impregnated bronze

Microscopic examination of porous bronze reveals that some of the pores and sections of solid bronze are much larger than the diameter of balance staff journals used in watches. For this reason the material is not suitable for small diameter parts. Also, because of comparatively poor friction and wear properties, porous bronze impregnated with either PTFE or molybdenum disulfide cannot be recommended.

Impregnated carbon

In general, the metal-impregnated carbon materials have good friction and wear characteristics. They also have a low coefficient of thermal expansion, and in some applications their good electrical conductance may be useful. Because of lack of homogeneity and relative coarseness of structure, these materials cannot be recommended for very small bearings (less than 1/16-in. bore).

Wear Rates of Bearing Materials ➡

⬇

THRUST BEARING MATERIALS[a]

Bearing	Time Run, days	1000-Gm Load		1240-Gm Load		Avg Wear Rate, in./yr.
		Depth of Wear, in.	Pressure, psi	Depth of Wear, in.	Pressure, psi	
PTFE	20	0.011	266	0.010	363	0.110
	40	0.016	187	0.015	247	0.091
	60	0.020	180	0.020	223	0.082
PTFCE	20	0.009	323	0.0075	478	0.119
	40	0.013	228	0.011	330	0.068
	60	0.016	187	0.014	263	0.055
PTFE + 65% (31% by vol) Molybdenum Powder (0.5-5.0 μ)	20	0.0015	1875	0.0015	2326	0.018
	40	0.002	1418	0.002	1758	0.009
	60	0.002	1418	0.002	1758	0.000
PTFCE + 56% PTFE (fused at 500 F)	20	0.002	1418	0.002	1758	0.009
	40	0.002	1418	0.002	1758	0
	60	0.002	1418	0.002	1758	0
PTFE + Glass Fiber + Other Fillers	20	0.0015	1875	0.002	1758	0.009
	40	0.002	1418	0.002	1758	0.005
	60	0.002	1418	0.0025	1393	0.005
Carbon + Graphite + Silver	20	0.002	1418	0.0015	2326	0.018
	40	0.0035	818	0.0015	2326	0.014
	60	0.004	715	0.0015	2326	0.005
Polished Sapphire[b]	20	0.005	574	—	—	0.036
	40	0.007	412	—	—	0.036
	60	0.0095	311	—	—	0.046
Polished Diamond	20	—	—	0	139,300	0
	40	—	—	0	139,300	0
	60	—	—	0	139,300	0
PTFE + Green Pigment Enamel (fused on brass)	4	0.031	180	0.027	233	2.65
PTFCE + 20% Graphite Coating (fused on brass)	10	0.010	292	0.016	232	0.475

[a] Against hardened 440C stainless steel shaft with ⅛-in. end radius; shaft oscillates at 1 cps with 1.5 radian amplitude.

[b] Wear occurred on end of steel pin instead of on sapphire endstone.

Other materials

No material has been found as satisfactory as diamond for thrust bearings operating under high load conditions such as occur at the upper endstone of balance shafts in chronometers. Also, no material has been found as satisfactory as sapphire for use as pallet stones in timepieces. Sapphire appears to be suitable for use as unlubricated endstones under relatively light loads, especially in timepieces normally operating in an upright

JOURNAL BEARING MATERIALS[a]

Material	Shaft Material	Estimated Time to Produce 0.005-in. Radial Wear, hr				Rating[b] at 150 Rpm
		15 Rpm	150 Rpm	700 Rpm	1800 Rpm	
Polytetrafluoroethylene (PTFE)	303	1400	25	—	—	5
PTFE + 13% Glass Fiber (0.05μ avg dia)	303	60,800	7020	2430	962	3
PTFE + Glass Fiber + Pigment	303	95,400	12,700	—	—	2
PTFE + Glass Fiber + Molybdenum Disulfide (MoS_2)	303	58,100	3710	1340	—	3
PTFE + 18% Titanium Dioxide (TiO_2) + 4% Polymethylsiloxane	303	19,100	119	—	—	4
PTFE + MoS_2	303	30,500	480	—	—	4
PTFE + 73% (40% by vol) Molybdenum Powder	303	100,000+	100,000+	—	—	1
PTFE + 63% (29% by vol) Mo Powder	303	—	26,800	—	94	2
	440	—	1660	—	1510	3
	D3[c]	—	3750	—	1240	3
	C40[d]	—	100,000+	—	21	1
PTFE + 70% (34% by vol) Mo + 6% Chromium Tetrahydrate	303	100,000+	1630	—	—	3
PTFE + 36% Silicon Powder	303	4450	1660	166	—	3
PTFE + 25% Dental Silicate	303	13,000	16,600	1400	—	2
	D3	—	—	—	2	—
PTFE + 67% (33% by vol) Copper Powder	303	21,500	203	99	—	4
PTFE + 80% (52% by vol) Tin (fused at 700 F, 10,000 psi)	303	113	35	—	—	5
PTFE + 28% (18% by vol) TiO_2	303	18,900	2070	—	—	3
PTFE + 18% TiO_2 + 11% Chlorinated Biphenyl	303	5790	236	—	—	4
PTFE + Graphite	303	45,700	12,200	—	—	2
PTFE + Copper Powder	303	2230	910	—	—	4
PTFE + 90% (50% by vol) Tungsten Powder	303	8000	1280	—	—	3
PTFE + Green Pigment Enamel (fused on brass)	303	—	5220	—	166	3
PTFE + Clear Coating (fused on brass)	303	—	630	—	3	4
Polytrifluorochloroethylene (PTFCE)	303	1340	116	—	—	4
PTFCE + 10% PTFE (fused at 500 F)	440C	—	870	—	130	4
	303	—	2220	—	140	3
	C40	—	1220	—	140	3
PTFCE + 56% PTFE (fused at 500 F)	303	11,400	8700	11,400	1220	3
	440C	—	1880	—	247	3
	D3	—	1830	—	415	3
	C40	—	3810	—	507	3
PTFCE + 51% PTFE + 10% Glass Fiber (fused at 500 F, 13,000 psi)	303	26,100	14,000	2150	—	2
PTFCE + 14% (27% by vol) PTFE + 64% (28% by vol) Molybdenum	303	63,100	11,300	286	—	2
PTFCE + Mo S_2	303	10,600	2120	48	—	3
PTFCE + 51% PTFE + 13% Chromium Tetrahydrate	303	31,800	11,900	21	—	2
PTFCE + Graphite	303	2050	182	—	—	4
PTFCE + 20% Graphite Coating (fused on brass)	303	—	11,600	—	513	2
Nylon, Molded	303	1440	103	—	—	4
Nylon, Sintered and Machined	303	1160	99	—	—	5
Nylon, Sintered after Machining	303	1570	—	—	—	—
High Density Polyethylene	303	—	360	—	27	4
Carbon + Graphite + Silver	303	14,600	13,300	334	—	2
Electrographitic Carbon + Silver	303	19,400	3230	—	—	3
Carbon + Graphite + Babbitt	303	41,500	5810	—	—	3
Electrographitic Carbon + Babbitt	303	5740	313	—	—	4
Sintered Porous Bronze + Molybdenum Disulfide	303	—	52	—	—	5
Bearing Bronze: 83 Copper—8 Tin—8 Lead	303	—	50	—	—	5
Tungsten + MoS_2 + Plastics Coating (on brass)	303	—	0.9	—	—	5

[a] ¼-in. shafts, room temperature, 2000-gm load.

[b] 1:100,000+ hr., excellent; 2:10,001 to 100,000 hr., very good; 3:1,001 to 10,000 hr., good; 4:101 to 1000 hr., fair; 5:0 to 100 hr., poor.

[c] D3 — Oil hardened, high chromium tool steel, Rc 60.

[d] C40—40 cobalt—20 chromium—15 nickel—7 molybdenum—2% manganese alloy, Rc 58.

position.

Despite its exceptionally low friction at room temperatures, silver amalgam has proved very brittle and hole edges have chipped badly during boring and reaming operations. An amalgam of dental alloy filings has been found less brittle, but it undergoes an increase in its friction coefficient and becomes scuffed shortly after operation is started.

Stretch forming *titanium alloy part in a 500-ton Sheridan press.*

Titanium Alloy Suited for Stretch Formed Parts

Preliminary tests indicate 6 aluminum–4% vanadium alloy can be formed with standard tools and techniques.

by Eric J. Carr, *Manufacturing Engineer, Pilotless Aircraft Div., Boeing Airplane Co.*

■ Stretch forming of titanium-aluminum-vanadium alloy sheet (Ti 6A1-4V) can be done satisfactorily at room temperature using conventional tools and methods. Edge preparation, surface condition and thickness variation offer no greater problems than are encountered with aluminum. However, control of heat treated condition of the alloy and jaw grip are important in obtaining satisfactory results.

Stretch forming is used extensively in the production of double-contoured aluminum and magnesium skins for today's aircraft. Normal stretching operations are performed at room temperature on aluminum alloys and at about 350 F on magnesium.

Tougher alloys will be necessary for future aircraft, and Ti 6A1-4V gives excellent promise for this use. It retains a favorable strength-weight ratio to 1000 F, is heat treatable to 180,000 psi ultimate strength, and is readily weldable.

The measure of formability of a material is the spread between yield and ultimate strengths. Ti 6Al-4V has a relatively small range at a high value (120,000 psi tensile yield strength to 130,000 psi tensile strength, annealed) which indicates difficulty in forming. Preliminary testing has shown, however, that although high forming pressures are required, the material is readily formed within this range.

Forming tests

In the Boeing tests, as suggested above, stretch forming was accomplished with tools and parts at room temperature, using standard methods, tools and lubricants. All parts tested were successfully formed, although springback was not always removed before failure. All failures were in the excess metal or at the jaws.

A 30 by 60-in., double-contoured *Kirksite* block was used in the investigation. The parts were 0.050 in. thick, 12 in. wide and 50 in. long, allowing approximately 12 in. of excess. Parts were tested in three heat treated conditions:

	Yield Strength, 1000 psi	Tensile Strength, 1000 psi
Mill Ann.	120	130
Sol. Heat Treated	105	140
Aged Full Hard	150	180

The preliminary tests indicate that:

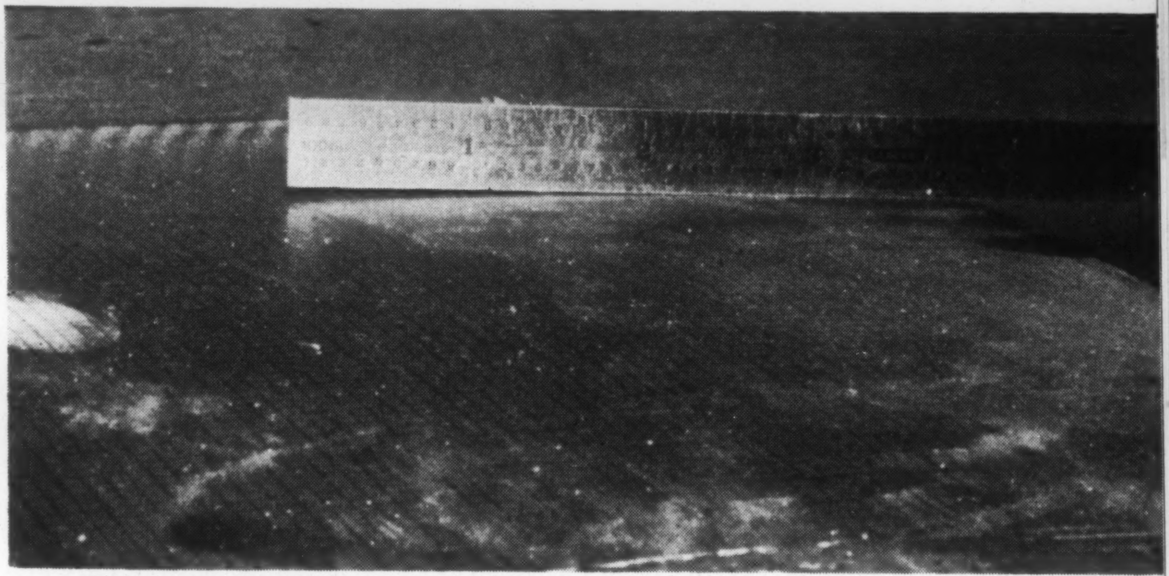
1. Graphite cup grease gives uniformly satisfactory results as a lubricant.

2. Gripping the part is more difficult than with steel or aluminum. Titanium shims or clean steel jaws give the best grip. A heavy (10,000 lb) jaw pressure is necessary, and shims used adjacent to the part should be thinner (up to 0.005 in. thinner) than the material.

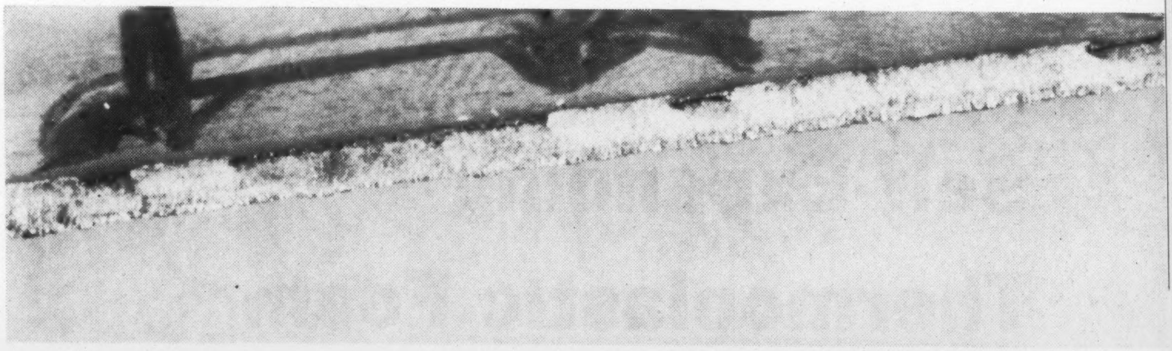
3. Edge preparation of the sheets is not as critical as previous information has indicated. Several sheets with sheared edges and two having severe edge notches were successfully stretched with no failure at the notches.

4. Mill annealed and solution heat treated parts are readily formed. Very little strain hardening occurred in either condition and ductile failures were typical, with local elongations as high as 18% in 1 in. Parts heat treated flat, as received from the mill, showed much less distortion than those heat treated after forming. The aging cycle produced very little distortion in unrestrained parts.

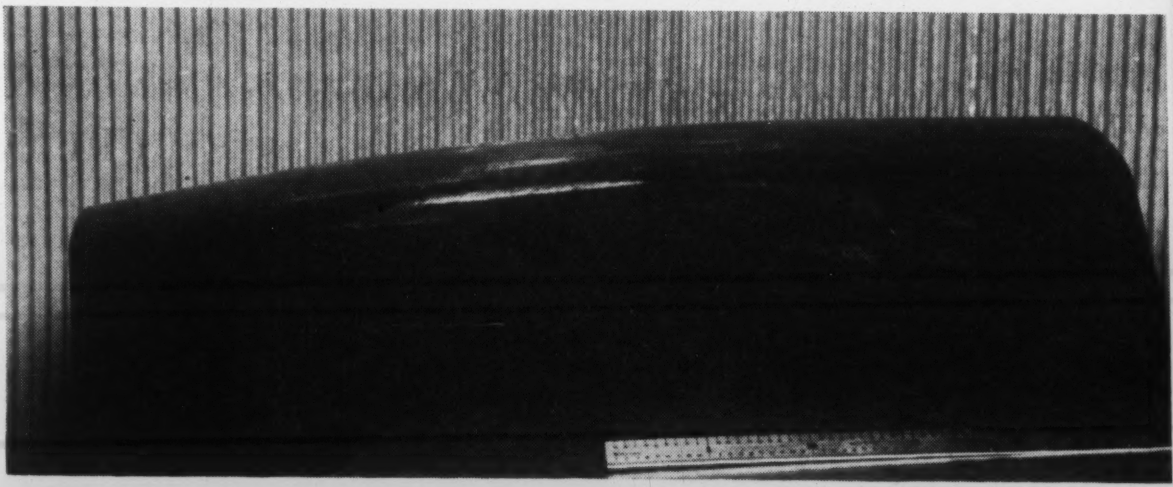
5. Springback is not easy to remove in full hard parts. An attempt was made to set formed parts after aging to the full hard state. These parts had edge curl ½ to 1½ in. wide. They pulled down to the block, but broke at the jaw as additional pressure was applied. Springback was not visibly reduced.



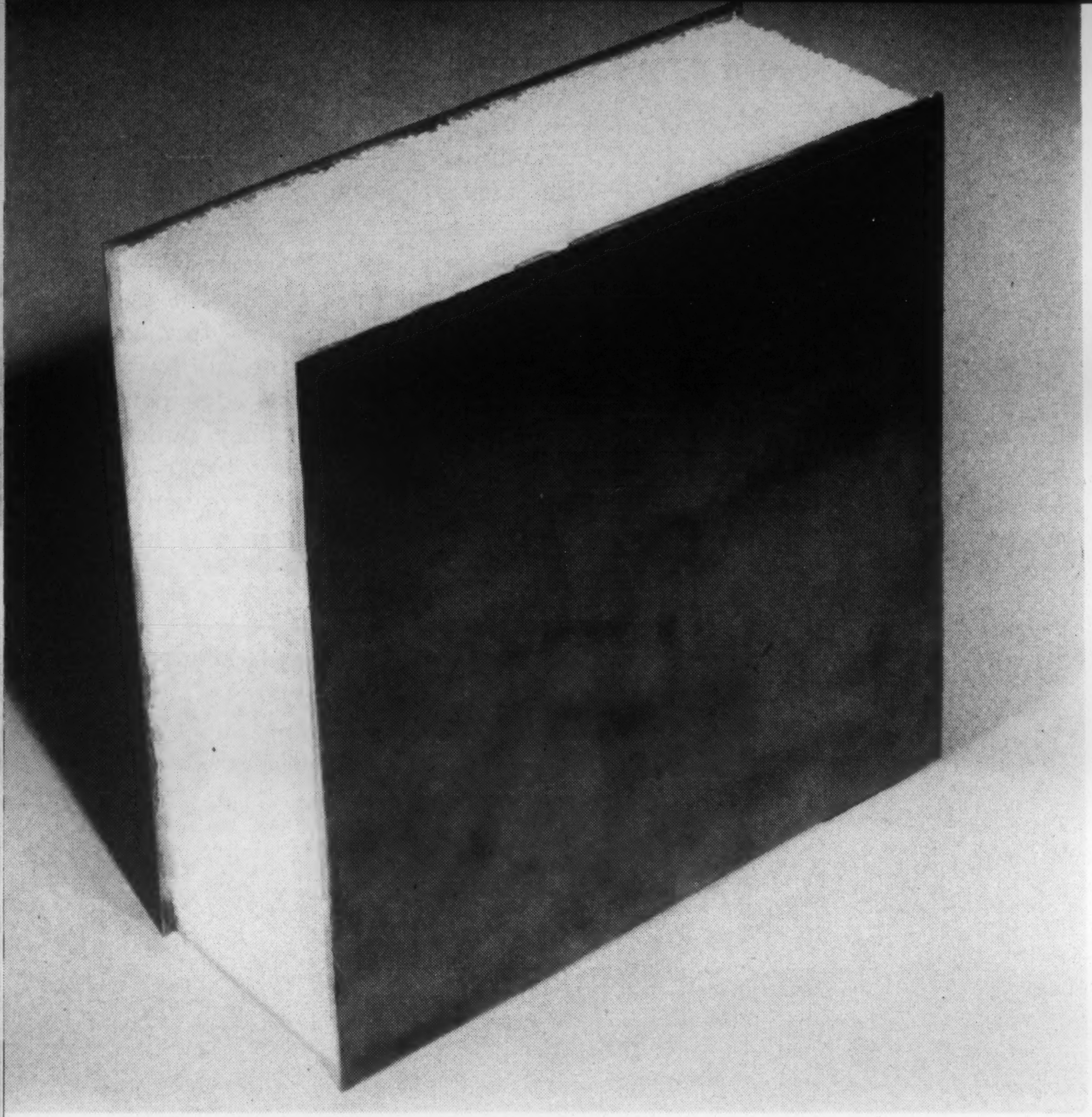
Springback, *shown here by transverse contour of part, varies from about ½ to 1½ in. on each edge.*



Edge condition *of the sheet is not critical in forming mild contoured parts. Note bad sheared condition.*



Contour *across center of stretch formed titanium alloy sheet.*



***Sandwich structure** of the new foam is not only easy to make but also has unusually good stress distribution under load. Sandwich shown here has stainless steel facings.*

Polystyrene Beads + Thermosetting Resin =

Self-Expanding Thermoplastic Foam

Unlike currently available thermoplastic foams, this new material can be foamed in place without external heat or gas. It looks promising for sandwich structures and other uses.

by D. L. Graham, *Dow Chemical Co.*

■ A new plastics foam system, now under development, expands without the use of external heat to form a lightweight, structural foam. The system combines expandable polystyrene beads and an exothermic type thermosetting resin. When the two are mixed, and a curing agent and modifier added, the heat produced by the cure of the resin expands the beads to form the foam. As the beads expand they force most of the resin out to form a hard, chemical resistant surface on the part. The remainder of the resin acts as a binder and reinforcement between the individual expanded beads.

The new foaming method will work with several polymer systems. The two main requirements for success are: 1) the thermosetting resin must not chemically attack the gas-containing thermoplastic granules, and 2) the heat of reaction produced during the cure must be sufficient to soften and expand the granules. Because of the suitability of epoxy systems in such foams, the discussion in this article concerns polystyrene bead-epoxy combinations.

Characteristics

Unicellular foams produced by such systems have the following characteristics: 1) good adhesion to metals, glass, wood and several types of plastics, 2) good structural strength, 3) low water absorption, 4) low thermal conductivity, 5) no mold shrinkage, 6) good chemical resistance, and 7) wide density range.

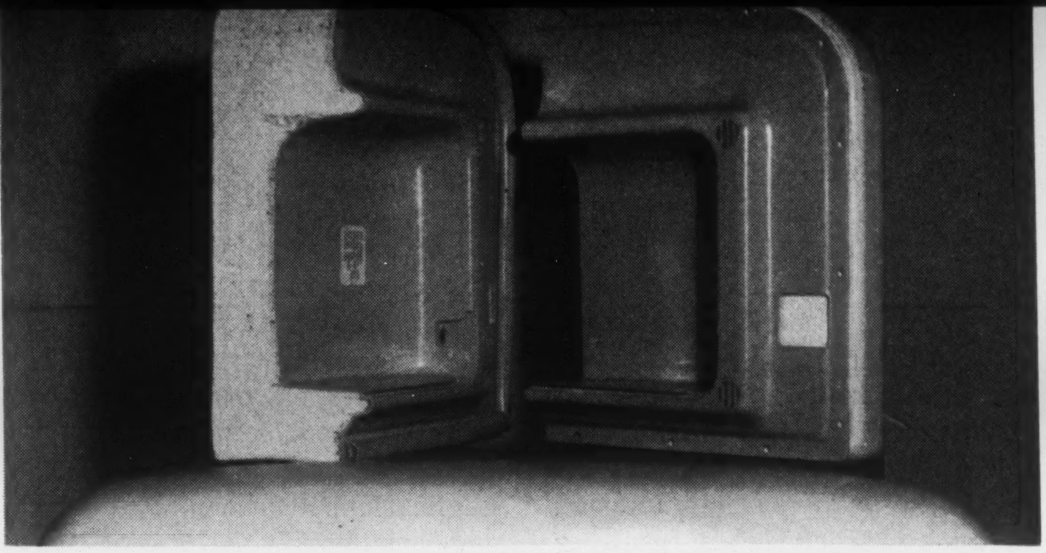
The accompanying table compares the property range of these foams with those of two other types of polystyrene foams. Fig 1 and 2 show how compressive strength and heat distortion temperature vary with bulk density.

Water resistance of the foams is excellent due to both the hard epoxy surface and the non-interconnecting nature of the cells. As in other polystyrene foams, thermal conductivity is low—on the order of 0.24 Btu/hr/sq ft/°F/in.

Densities range from approximately 5 to 20 lb per cu ft. To date, 1.4-mm dia beads have been

Availability

The foam materials described in this article are in the early stages of development and are in very limited supply. According to Dow, the methods, composition and products described are the subject of pending application for patents in the United States and principal foreign countries.



Low temperature insulation *is expected to be a major application for the foam. These developmental parts have molded polystyrene facings.*

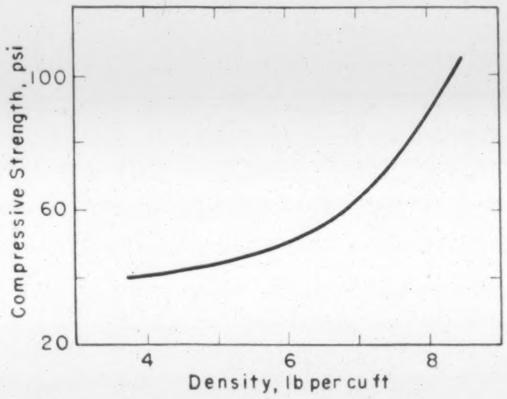


Fig 1*—Compressive strength, measured at 2.5% deformation, varies with density.*

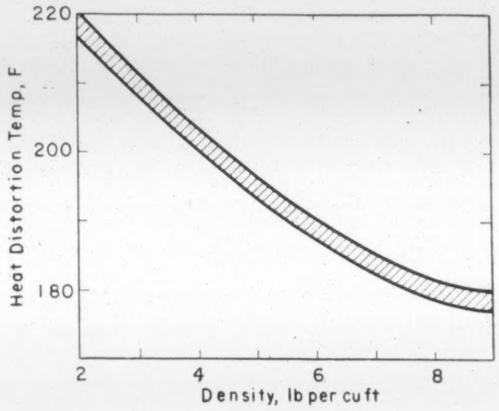


Fig 2*—Heat distortion temperature also varies with density.*

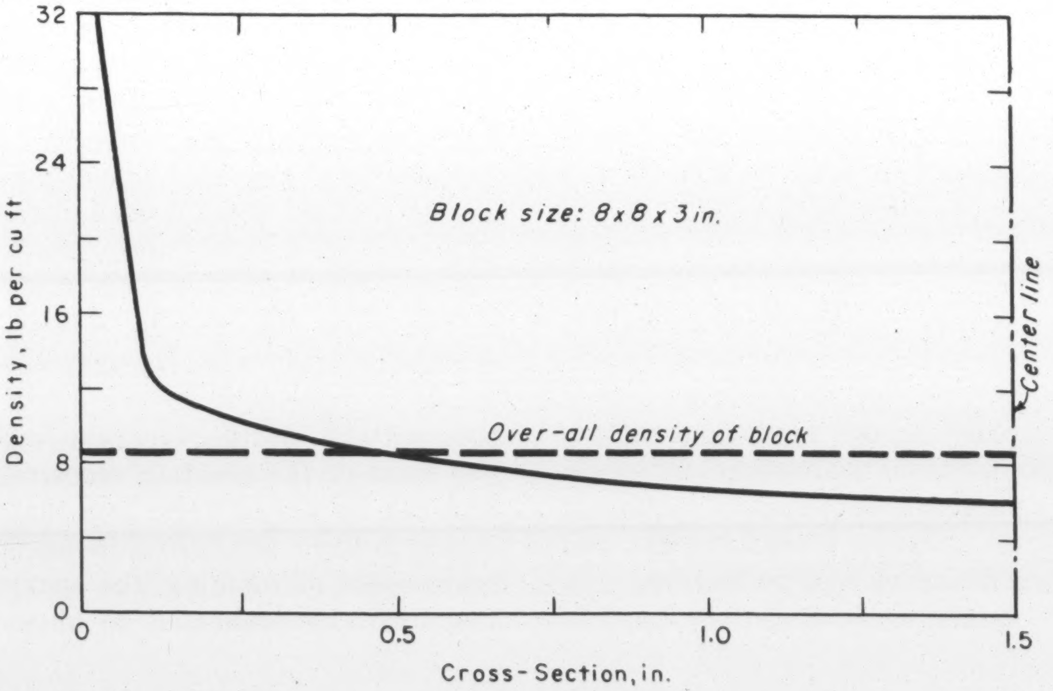


Fig 3*—Density gradient of typical sample measured from the outer surface to the centerline.*

used to produce minimum densities of 6 to 8 lb per cu ft, whereas beads of 2.8 mm dia produce densities as low as 5.0 lb per cu ft. Density of a given molding is determined by 1) mass of the charge to the mold, 2) temperature of the resin, 3) temperature of the mold, 4) type of polystyrene bead used, 5) bead-resin ratio, 6) geometric shape of the mold, and 7) surface area-volume ratio.

Because of the resin-rich surface and the fact that fewer expanded beads are present near the surface, there is a density gradient throughout the structure of the foam. The gradient of a typical molded foam is shown in Fig 3. This gradient provides unusual strength characteristics which are particularly advantageous when the foam is used as a core material in sandwich structures. Because of the gradient, shear moduli increase from the center of the foam to the surface, providing a more balanced stress distribution under load. Though this increase in moduli is not linear, it is definitely an improvement over the typical sandwich which has a core of uniform density.

Potential uses

Though the foams are still under development, they look promising for a variety of applications. Since they are structural foams, they should not be considered as a replacement for nonstructural void fillers. Properties of polystyrene-epoxy foams suggest applications such as sandwich structures, low temperature insulation, buoyant structures, and chemical resistant structures.

Sandwich structures—In addition to the good strength properties of the foams, the fact that expansion requires no external heat source is clearly advantageous in fabricating sandwich structures. Also, the epoxy resin provides excellent adherence to a variety of facing materials. Rigid materials such as stainless steel, aluminum, galvanized iron, glass, wood and high impact plastics sheet have been used successfully in combination with the foam.

Panels with glass-reinforced facings can be produced by an interesting one-step operation. Dry glass cloth is placed in either or both surfaces of the mold. During the foaming process the resin is driven to the mold surface and saturates the cloth. Such panels are lightweight, are good thermal insulators, are protected on both sides by a reinforced structural skin, and have the unusual strength characteristics resulting from the density gradient of the core material. Applications for such sandwich structures include truck bodies, boats, furniture and aircraft.

Low temperature insulation—The unicellular construction, structural strength and low thermal conductivity of the foam also make it a promising material for refrigeration applications such as doors, cabinets, freezer lids and evaporator doors. Several prototypes of refrigeration parts have been made to demonstrate the material's adaptability to this use. A refrigerator door has been produced by expanding the foam between molded high impact polystyrene sheets. The outer and inner door liners, held by retaining molds during the molding operation, were formed prior to foaming. Doors have been formed successfully with molded-in lock mechanisms, latches, hinges, gaskets and fixtures. Again, the epoxy resin driven to the surface provides the adhesion to bond the inserts firmly in place. Thus, complete refrigerator doors can be molded in one operation without an external heat source. Other potential low temperature insulation uses include transportation, air conditioning and packaging.

Other uses—Buoyancy applications include boats, boat buoys, floats, pontoons, life preservers, water sports equipment, and flotation chambers in marine construction. Many other applications, such as reinforcement of sheet metal parts, encapsulation of electrical components, anticorrosive structures, and shock absorption applications in automobiles, are being considered.

Molding considerations

To mold a part, expandable polystyrene beads, thermosetting resin, curing agent and modifier are blended thoroughly and charged to the mold. The mold should be temperature-controlled and designed to withstand foaming pressures that are on the order of 10 to 50 psi, depending on density. Because of the adhesive nature of epoxies, molds used repeatedly must be provided with coatings of polytetrafluoroethylene, silicone, or other commercially available mold release agents.

Good foaming efficiency requires control of: 1) temperature of the reactants, 2) mass of the reaction mixture, 3) geometric shape of the mold, 4) mold temperature, and 5) thoroughness of mixing. These are the factors that determine completeness of mold filling, general moldability, voids, density, bonding to surface skins, speed of foaming and over-all cure time.

Formulation

The typical polystyrene bead-epoxy foam discussed in this article is Dow Experimental Plastic Q-4124.1. It is composed of four components in the following proportion (expressed as parts by weight):

Epoxy resin (Experimental Plastic Q-4115.2)	100
Expandable polystyrene beads (Experimental Plastic Q-865.2)	120
Curing agent (Dow ET-82)	20
Modifier (Dow ET-83)	10

The resin-bead ratio may be varied from 1:1 to 1:2 to obtain a range of densities and physical properties in the finished molding. A resin-bead ratio of less than 1:1 generally will not permit generation of sufficient exotherm to expand the beads. Generally the best foaming occurs when a 1:1.2 resin-bead ratio is used. Expandable beads measuring 1.4 and 2.8 mm dia may be used, either individually or in combination, to obtain various densities and physical properties. In general the larger diameter beads provide lower densities than the smaller beads.

The time required to produce expansion of the polystyrene beads is dependent on the initial temperature of the reactants and the mass of the reaction mixture, and can be varied from less than 1 min to about 15 min. For maximum speed of foaming, the epoxy resin can be preheated to about 195 F. Preheating also lowers the viscosity of the resin, simplifying handling and mixing.

For optimum expansion, molds should be insulated or heated to reduce the loss of exothermic heat. Coring provides an efficient method of heating and cooling the molds for optimum moldability and shortest over-all cycle time.

When foaming between thin, flexible facing materials, it is well to back the facings with retaining molds to prevent distortion; facings of complex shape should be held against retaining molds securely. Use of retaining molds is particularly important in foaming against thermoplastic skins, since they would be likely to distort from the combination of temperatures and pressures produced by the reaction.

Adapted from a paper presented at the 13th National Technical Conference, Society of Plastics Engineers, Jan '57.

COMPARISON OF PROPERTIES OF POLYSTYRENE FOAMS

Property	Beads and Resin (Exp. Plastic Q-4124.1)	Molded Beads	Pre-Expanded
Density, lb/cu ft	5–20	1.0–10.0	1.5–4.5
Compressive Strength, psi	45–150	8–250	16–140
Thermal Conductivity, Btu/hr/sq ft/°F/in.	0.24	0.22–0.27	0.25–0.28
Water Absorption, lb/sq ft surface area	<0.01	<0.02	<0.20
Heat Distortion, Temp F	180–195	180	175

Source: Franson, G. R. and Kennedy, N. R., "Polystyrene — Versatile Foaming Material", presented at 13th National Technical Conference, Society of Plastics Engineers, Jan. '57.

M & M
MANUAL

General Electric Co.

Varnished cambric tapes *are used to insulate these electrical coils.*

Electrical Insulation Materials

by A. J. Monack, *Dept. of Physics, Newark College of Engineering*

This manual is a survey of the major types of solid insulation materials and their electrical, mechanical and thermal properties. The discussion covers all common forms: films, sheets and slabs, tapes, sleeving and flexible tubing, rigid tubing, rods and moldings. Information is arranged in a systematic pattern to aid the engineer in selecting the optimum insulation for a specific application.

MATERIALS & METHODS MANUAL NO. 137—APRIL 1957

TABLE 1—INITIAL SELECTOR CHART

Insulation Form / Temperature Range	Films	Sheets and Slabs	Tapes	Sleeving and Flexible Tubing
Below 500 F	Polytetrafluoroethylene (H) Polytrichlorofluoroethylene (M) Polyamide (M) Polyester (M) Cellulose triacetate (M) Cellophane (M) Polyvinyl chloride (L) Polyvinyl chloride-acetate (L) Vinylidene chloride (L) Cellulose acetate (L) Cellulose acetate butyrate (L) Rubber (L) Polyethylene (L) Ethyl cellulose (L) Polystyrene (L)	Polytetrafluoroethylene (H) Pasted mica, silicone bonded (H) Glass-silicone laminate (H) Glass-polytetrafluoroethylene laminate (H) Polytrifluorochloroethylene (M) Polyamide (M) Vulcanized fibre (M) Wood (L to M) Pasted mica, organic bonded (L to M) Plastics laminates (L to M)[b] Cellulosic (L) Polystyrene (L) Methacrylate (L)	Polytetrafluoroethylene (H) Polytrichlorofluoroethylene (M) Polyamide (M) Cellophane (M) Polyester (M) Paper (L) Woven acetate fiber (L) Cellulose acetate (L) Ethyl cellulose (L) Rubber (L) Woven cotton (L) Polystyrene (L) Polyvinyl chloride (L) Polyvinyl chloride-acetate (L) Polyethylene (L)	Polytetrafluoroethylene (H) Polytrichlorofluoroethylene (M) Silicone rubber (M) Polyamide (M) Woven polyester fiber (M) Braided cotton (L) Braided rayon (L) Braided silk (L) Braided linen (L) Woven acetate fiber (L) Polyvinyl chloride (L) Natural rubber (L) Synthetic rubber (L) Polyethylene (L)
500 to 1000 F	Ribbon glass (M)	Ceramoplastics—glass bonded micas (M to H) Muscovite mica—small sheets (M to H) Pasted muscovite mica, inorganic bonded (M to H)	Ribbon glass (M) Woven glass fiber (L to H) Woven asbestos (L to H)	Woven asbestos (L to H) Woven glass fiber (L to H)
Above 1000 F		Ceramics—small slabs only (H) Glass (L to H) Amber mica—small sheets (M) Pasted amber mica, inorganic bonded (M) Built-up synthetic mica, inorganic bonded (M) Reconstituted mica, inorganic bonded (L to M)	Woven fibrous silica (H)	Woven fibrous silica (H)

[a] Letters L, M and H after each material indicate portion of temperature bracket for which insulation is suitable—lowest, middle or highest. After most of the possible insulations have been eliminated on the basis of their form and maximum temperature, further selection can be made by referring to the mechanical, physical and electrical properties listed in the other charts in this article.

■ The primary function of an electrical insulation is to confine the flow of a current to a desired path. In performing this function the insulation may also serve as a structural element by maintaining spacings or positions. Electrical insulation is also used to protect the surfaces of conductors from adverse environments such as moisture and chemicals, and to fill spaces or voids where corona discharge is liable to occur.

In general, electrical insulations are classified as gases, liquids or solids. Data presented in this manual will be confined to the most widely used, or solid, forms. Chemically, these solid insulations may be organic, inorganic, or combinations thereof. Many of the electrical and physical properties of organic and inorganic insulations overlap; the most striking differences are in resistance to heat and in permanence of size and shape.

In organizing these data it has been assumed that the most convenient method of selecting an insulation material is to consider first the form or shape it must have and the temperature requirements it must meet. Certain electrical, physical or mechanical requirements, of course, may dictate the choice of material; however, the approach used in this article is usually more convenient.

Once the parameters of form and temperature have been established, a considerable number of materials can be ruled out as unsatisfactory. Selection from the remaining materials can then be made on the basis of their electrical, mechanical and thermal properties.

FOR ELECTRICAL INSULATIONS[a]

Rigid Tubing	Rods	Moldings
Polytetrafluoroethylene (H) Glass-silicone laminate (H) Pasted mica (M to H) Polyamide (M) Vulcanized fibre (M) Polytrichlorofluoroethylene (M) Plastics laminates—grades XX, XXX, C, CE, L, LE, G3, G5, G6, G7, N1 (L to M)[c] Methacrylate (L) Polystyrene (L) Polyvinyl chloride (L) Polyvinyl chloride-acetate (L) Cellulose acetate butyrate (L) Pasted mica paper (L)	Polytetrafluoroethylene (H) Glass-polytetrafluoroethylene laminate (H) Polytrichlorofluoroethylene (M) Vulcanized fibre (M) Polyamide (M) Plastics laminates—grades XX, XXX, C, CE, L, LE, G3, G5, G6, G7, N1 (L to M)[c]	Polytetrafluoroethylene (H) Organic cold molded (H) Silicone, glass fiber or mineral filled (H) Diallyl phthalate (H) Polytrichlorofluoroethylene (M) Alkyd, glass fiber or mineral-filled (M) Phenol-formaldehyde (M) Melamine-formaldehyde (M) Polyamide (M) Pasted mica (L to H) Aniline-formaldehyde (L) Urea-formaldehyde (L) Hard rubber (L) Polyethylene (L) Polyvinyl chloride (L) Polyvinyl chloride-acetate (L) Vinylidene chloride (L) Polystyrene (L) Cellulosic (L)
Pasted mica, inorganic bonded (H)	Ceramoplastics—glass bonded micas (M to H)	Ceramoplastics—glass bonded micas (M to H) Inorganic cold molded (M to H) Glasses, low temperature (M to H)
Ceramics (H) Glass (M to H)	Ceramics (H) Glass (L to H)	Steatite (H) Fluxed alumina (H) Cordierite (H) Titanate ceramics (H) Forsterite (H) Zircon porcelain (H) Lithia porcelain (H) Pure oxides (H) Synthetic micas, hot pressed (M) Electrical porcelain (M to H) Glasses (L to H)

[b] All other grades besides those listed above.

[c] Based on NEMA recommendations for industrial laminated thermosetting products. Other special grades are available from laminates manufacturers.

Table 1 has been prepared to aid the designer in this selection process. In this table, the various types of insulation are grouped according to their forms and temperature limits. Detailed data on these insulations can be found by consulting the appropriate properties charts and the following discussion.

Elastomers and Flexible Plastics

These materials (see Table 3) are used chiefly for wire and cable insulation; occasionally they are used for plugs and connectors, and in housings for electrical and electronic components. Fabrics are often used with the wire and cable covering materials to increase their mechanical strength and resistance to cut-through.

Elastomeric insulations are capable of being stretched repeatedly to 150% or more of their normal length with no permanent set or loss of force. The natural elastomeric materials in common use include: natural rubber, gutta-percha, balata and paragutta. Synthetic elastomeric materials include: styrene, acrylonitrile, neoprene, butyl, silicone and polysulfide rubbers. Polyvinyl chloride and its copolymers, polyethylene and the polyfluoroethylenes are commonly used flexible plastic insulations.

Waxes

Insulating waxes are used in bulk form as potting compounds or as thin coatings to prevent the formation of continuous films of moisture. In recent years their use has diminished somewhat due to the superiority of a number of organic resins. The epoxies are considerably superior to waxes for potting; and silicone, fluorocarbon and other resins are much more satisfactory for the formation of hydrophobic surfaces. Typical properties of representative types of insulating waxes are listed in Table 2.

Paper

The chief function of paper is that of a separator or as a wrapping for wire insulation. Untreated paper is roughly equivalent to air as an insulator and when completely dry its resistivity is good—about 10^{15} ohm-cm. Untreated paper usually contains 7-12% moisture and, because of its absorption tendencies, it is usually treated, even when it is serving only as a separator. The electrical properties of papers treated with varnish or lacquer essentially match those of the treating materials.

Electrical properties and maximum operating temperatures of a wide range of insulating papers are listed in Table 4. (Properties of papers used in composite insulations are given in Table 6.)

Insulating papers may be divided into inorganic and organic (cellulosic) materials. The inorganics are preferably treated with silicone varnishes or fluorocarbons, but may be treated with epoxy or polyester resins. Organic

TABLE 2—PROPERTIES OF ELASTOMERS AND FLEXIBLE PLASTICS

(See also page 147)

Material \ Property	Max A.C. Volt, kv	Dielec Const (60 cps)	Power Factor (60 cps)	Dielectric Strength, v/mil		Vol Res, ohm-cm	Water Perm (7 days), mg/sq in.	Water Abs (24 hr), %	Max Svc Temp, F	Min Svc Temp, F	Brittle Temp, F
				A.C.	D.C.						
Natural Rubber	3[a]	2.6-5	0.008-0.040	600	1500	10^{17}	7	—	167	−40	−72
GR-S Synthetic Rubber	3[a]	2.7-5	0.009-0.040	600	1500	10^{15}	8	—	167	−65	—
Butyl Synthetic Rubber	28	3-5	0.01-0.04	400	1000	10^{16}	5	—	176	−40	−58
Neoprene	0.6	7	0.02	300	—	10^{12}	25-100	—	194	−22	−40
Silicone Rubber	5	3	0.007	260-700	—	10^{14}	—	0.25-1.00	392	−67	−121
Polyvinyl Chloride	0.6	5-6	0.10-0.15	300-800	2000	10^{12}-10^{14}	5	0.3	149-176	−22 to +41	+6 to −67
Polyvinyl Chloride-Acetate	0.6	5-9	0.08-0.15	400-900	—	10^{11}-10^{13}	—	0.1	149-176	—	—
Polyethylene	15	2.3	0.004	400-1200	—	10^{13}	1	Slight	176	−76	−94
Polytetrafluoroethylene	5	2.0-2.2	0.0005	450-900	—	10^{16}	—	Nil	392	−67	−103
Polytrifluorochloroethylene	5	2.3	0.015	500-900	—	10^{18}	—	Nil	302	−65	—
Gutta-percha	0.6	2.56-4.13[b]	0.0009-0.0300[b]	200-500	—	10^{15}	—	—	140	14	−9 to −33
Polysulfide Rubber	—	7-9.5[b]	0.001-0.005[b]	250-350	—	10^{11}-10^{12}	—	—	275	−65	—

[a] 28 kv for ozone resisting grade.
[b] 1000 cps.

TABLE 3—PROPERTIES OF WAXES

(See also page 147)

Type	Dissipation Factor		Dielectric Constant		Volume Resistivity, ohm-cm	Surface Resistivity, ohm/square		Melting Point, F
	60 cps	10^6 cps	60 cps	10^6 cps		50% R.H.	90% R.H.	
Beeswax	—	0.01-0.03	2.8-3.1	2.5-2.9	10^{14}-10^{15}	6 x 10^{14}	5 x 10^{14}	113-147
Paraffin	0.0002-0.0090	0.0002-0.0090	2.1-2.5	2.1-2.5	10^{14}-10^{16}	9 x 10^{15}	6 x 10^{15}	97
Cerese Wax	0.0009-0.0060	0.0004-0.0030	2.3-2.6	2.3-2.6	10^{18}	10^{17}	10^{17}	135
Cetylacetamide	0.025	0.002-0.005	2.6	2.4-2.5	—	—	—	282
Chlorinated Naphthalene	0.002-0.100	0.0001-0.005	3.1-5.6	2.9-5.4	10^{13}-10^{14}	6 x 10^{15}	5 x 10^{11}	95-201
Hydroxystearin	14.2	0.027-0.340	0.12	3.1-3.2	—	—	—	189
Polybutene	0.0002	0.001	2.3	2.3	—	—	—	—

papers are treated with conventional (oleoresinous) or thermosetting varnishes and include:

Kraft paper, usually consisting of a tan sulfate paper which is easily impregnated with varnish. It is commonly used for cable and wire insulation, for wrapping coil layers, and as a backing for composites. It is also used as a base for laminated plastics sheets and tubes.

Rag paper posesses good abrasion resistance and consequently is useful for slot insulation. It is also good for spacers and washers. Very thin (0.0005 in.) condenser papers may be either all rag or rag plus pulp.

Fish paper is a special electrical grade of vulcanized fibre and is excellent for slot and cell liners.

Rope (Manila) paper is made of Manila hemp or old rope. Because of its long fibers it is the strongest of the papers and is used in cables, in composites, and in slot, cell and core insulation.

Japanese (Jap) paper is made from mulberry wood pulp. In 1-mil thickness it is used as a backing for mica flake.

Pressboard or fuller board is made from rag, or rag plus pulp, and is readily impregnated with oil. The rag board is easily formed and bent, whereas the pulp board is somewhat stiffer. These materials are chiefly used for transformer insulation; they are also useful for spacers, collars, shields, etc.

Fabrics

Untreated fabrics are used in the form of cords, sleevings, tapes and threads as components in wire coverings and as wrappings in oil filled transformers. Fabrics in the form of cloths, tapes, ribbons and sleevings are used extensively as carriers for impregnating insulation materials; typical impregnants are oleoresinous varnish, silicone varnish, synthetic rubber and vinyl, isocyanate and polytetrafluoroethylene impregnants. Properties of the various treated and untreated fabric insulations are listed in Table 5.

Fabrics perform two other important functions in insulation. In the form of cloth they are used as base materials in plastic laminates (see Table 11). In the form of fibers, filaments and chopped fabrics, they act as reinforcements

TABLE 4—PROPERTIES OF PAPERS
(See also page 147)

Type of Paper and Treatment	Thickness, mils	Tensile Strength, lb/in. width	Dielectric Strength, v/mil	Insulation Class	Max Operating Temp, F	Dielectric Constant (60 cps	Power Factor (60 cps)
ORGANIC PAPERS							
Fish—Untreated	5	—	450	A	220	—	—
Rag—Untreated	7-20	—	300	A	220	—	—
Pressboard (rag and paper)—Untreated	31-125	—	150-200	A	220	—	—
Pressboard (yellow)—Untreated	10-125	—	200-500	A	220	—	—
Rag—Varnish	6.5-27	350-1600	300-460	A	220	2.0	—
Fish—Varnish	4-134	12-1800	150-300	A	220	2.0	—
Pressboard—Varnish	7-500	—	150-400	A	220	2.0	—
Kraft—Varnish	0.4-15	250-260	160-1100	A	220	2.0	—
Rope—Varnish	0.9-30	10-70	—	A	220	2.0	—
Japanese—Varnish	—	—	—	A	220	2.0	—
INORGANIC PAPERS							
Asbestos—Untreated	2-10	0.2-1.2	280-340	C	725	3.4	0.28
Mica—Untreated	1.5-4	0.2-0.7	500-700	C	900	1.2-1.6	0.0008-0.0015
Glass Fiber—Untreated	2-7	0.3-1.0	—	C	1100	1.07	0.0002
Ceramic—Untreated	5-80	0.1-1.0	—	C	2000	1.08	0.0002
Glass Flake—Alkyd	10	—	100	B	220	2.45	1.99
Glass Flake—Phenolic	9	—	120	B	220	1.93	1.26
Glass Flake—Silicone	9	—	105	H	500	1.91	0.96
Asbestos—Vinyl Acetate	3-15	8-35	290-370	B	340	—	—
Mica—Silicone	1.5-30	10	400-800	H	500	2-2.2.4	0.002-0.003
Mica—Epoxy	3-30	—	800	B	265	—	—
Glass Fiber—Silicone	—	0.6-6.4	—	H	500	—	—
Glass Fiber—Teflon	1.5-6.5	1.2-2.5	180-250	H	400	—	0.05-0.10
Ceramic—Silicone	12	4-6	—	H	500	—	—
Asbestos—Silicone	3-9	6-13	290-330	H	500	—	—

in plastic moldings (see Table 10).

Fabrics for electrical insulation are made from three types of fibers: natural organic, inorganic and synthetic organic.

Natural organic fibers employed for insulation fabrics are cotton, flax and silk. Because of its high cost silk has been replaced almost entirely by synthetic fibers.

Inorganic fibers are of two types: natural, such as asbestos, and manufactured such as glass.

Asbestos insulation is usually made in the form of roving, lap, yarn and cloth. It is often blended with cotton or other fibers to increase its strength and flexibility; these advantages, however, are gained at the expense of maximum service temperature. Insulation with a 75-80% asbestos content (Commercial Grade) has a service temperature of 400 F as compared to 900 F for 99-100% asbestos (AAAA Grade).

Glass fiber may be made from a number of glass compositions, including vitreous silica. Woven into cloth, treated and untreated glass fiber is used in a variety of applications where resistance to moisture and high temperatures is important.

Synthetic organic fibers and filaments that have proved useful for fabric insulation include rayon, nylon and cellulose acetate. Also used occasionally are acrylics such as Orlon or Acrilan, vinyls such as Saran and Vinyon, and polyesters such as Dacron.

TABLE 5—PROPERTIES OF FABRICS
(See also page 148)

Type of Fabric and Treatment	Dielectric Strength, v/mil	Thickness, mils	Breaking Strength, lb/in. width	Max Operating Temperature, F
Cotton—Untreated	50-100	3.5-25	20-40	195-220
Cotton—Varnish	400-1500	4.5-25	40-60	220
Rayon—Varnish	500-1200	2.2-22	25	220
Asbestos—Untreated	50-100	26-50	32-70	255-570
Asbestos—Varnish	400-1200	10-60	—	265
Asbestos—Silicone Varnish	700-1500	10-62	—	480
Linen—Varnish	250-500	8-10	—	220
Silk—Varnish	1000-1900	2-8	20	220
Glass—Untreated	50-100	1.5-25	70-450	535-570+
Glass—Varnish	500-1200	3-30	70-550	265
Glass—Silicone Varnish	1000-1500	3-30	70-450	480
Glass—Silicone Rubber	400-1200	4-32	40-500	480
Glass—Isocyanate	360-1300	3-23	—	300
Glass—Teflon	1200-1400	3-14	—	750
Fibrous Silica—Untreated	50-100	140-150	—	3630

Minnesota Mining and Mfg. Co.

***Yellow flatback paper** tape is used in this rotor to hold disk and insulate core from coil windings.*

Composite Insulations

Composite insulations possess a combination of properties not present in a single material. Typical of the composites commonly used are mica splittings, which are backed with or sandwiched between paper or fabric and held together by an oleoresinous varnish, shellac or similar material. Similarly, mica paper is strengthened by backings of glass cloth or polyester film on one or both sides, with an organic or silicone varnish as a binder. Properties of a number of important types of composites are listed in Table 6.

Electrical Tapes

In general, electrical tapes are used to insulate, to hold, or to serve as spacers. They are commonly employed for wrapping coils or conductors, for insulating splices, and for holding and binding insulating materials.

As can be seen from Table 7, electrical tapes are made from nearly all available plastics film materials (Table 9), as well as paper (Table 4), cloth (Table 5), composites (Table 6), and laminated and reinforced combinations (Table 8). Rubber tapes are also used extensively in insulation for wrapping and splices (their properties are essentially those given for elastomeric insulations in Table 3).

Glass insulation tapes are available in the form of flexible ribbon in thicknesses of 0.001 to 0.030 in., and in widths of 1/8 to 14 in. Within certain limitations, the thinner ribbons can be twisted,

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Basic Electrical Terms: What They Mean

Insulator—Commonly defined as a material with such low conductivity that it restrains or entirely prevents the flow of current. For practical purposes solids are divided into three classifications: conductors, with resistivities from 10^{-6} to 10^{0} ohm-cm; poor conductors (semiconductors) with resistivities from 10^{0} to 10^{6} ohm-cm; and good insulators, with resistivities from 10^{6} to 10^{20} ohm-cm.

Dielectric constant—The property that represents the electrostatic energy stored in a material per unit volume per unit potential gradient. At a given frequency it is the ratio of the capacitance of a capacitor in which the material is the dielectric to the capacitance of the same capacitor with a vacuum as the dielectric. For most purposes, air (instead of a vacuum) may be taken as the comparison dielectric.

Phase angle—The angular difference in phase between the sinusoidal voltage applied to the dielectric and the component of the resulting current. A perfect insulator would have a phase angle of 90 deg.

Loss angle—The difference between the phase angle and 90 deg (hence, the complement of the phase angle). A perfect insulator would have a loss angle of 0 deg.

Dissipation factor—The cotangent of the phase angle, or the tangent of the loss angle, for a given material. It is the reciprocal of Q, the quality factor, and is equal to the ratio of resistance to reactance. It is also the ratio of the energy dissipated to the energy stored per cycle.

Power factor—The cosine of the phase angle or the sine of the loss angle for a given material. It is the ratio of resistance to impedance. When the tangent of the loss angle is less than 0.1, the power factor differs from the dissipation factor by less than 0.0005.

Loss factor—Product of the dissipation factor and dielectric constant. It is a measure of actual loss in the insulation, since the dissipation factor is the fraction of energy lost during a cycle and the dielectric constant is proportional to the energy stored in the dielectric.

Dielectric strength—The maximum potential gradient that an insulator can withstand without rupture. It is commonly expressed in volts per mil. The relation between dielectric strength and thickness is not linear.

Volume resistivity—Ratio of d.c. potential gradient (parallel to the current in the insulation) to the current density. Commonly designated as microhm-centimeters.

Surface resistivity—Ratio of d.c. potential gradient (parallel to the current along the surface) to the current per unit width of surface. Commonly designated by ohms per square where the size of the square is immaterial.

Arc resistance—Total elapsed time until failure occurs when an arc is passed between two electrodes in contact with an insulation surface. ASTM standard test D-495 uses an arc of high voltage and low current and time to failure is measured in seconds. The insulation is said to "track" when a conducting path, usually the result of carbonization under the action of the arc, forms between the electrodes.

AIEE insulation classification—

Class	Material	Max Temp, F
O	Organic, not impregnated	195
A	Organic, impregnated	220
B	Inorganic, organic binder	265
H	Inorganic, silicone binder	355
C	Completely inorganic	355+

rolled and wrapped. Applications are limited somewhat by the inherent brittleness of the material; however, combination with a plastic can help to overcome this disadvantage.

Electrical tapes may be used without adhesive, or they may be coated with a pressure sensitive adhesive on one or both sides (for further data on electrical tapes see "Pressure Sensitive Tapes," M&M, Mar '56, p 136). Some of the pressure sensitive tapes available are: crepe and flatback paper; cotton, glass and acetate cloth; acetate and polyester film; acetate fiber; and Teflon.

Laminated tapes are made of two or more materials bonded together. Typical examples are acetate film laminated to rope paper, and acetate film laminated to acetate cloth. The acetate laminates have high strength, dimensional stability and resistance to water vapor.

Plastics Films, Sheets

Plastics insulating films and sheets are used primarily as wrappings for conductors. The materials used in these films and sheets are in nearly every case identical to the materials used in plastics insulation moldings. The difference is one of form.

Available film materials fall into the usual categories of cellulosics, vinyls, polyethylenes, styrenes, polyamides and polyesters. Rubber hydrochloride is also used because of its impermeability to moisture. Important properties of these materials are summarized in Table 9.

Plastics Moldings

Plastics for molded insulations are generally of the same type as used for other forms of insulation. The thermosetting plastics used in filled molded insulations, for example, are not different from those used in insulation laminates.

The important physical and electrical properties of the various types of molded plastics insula-

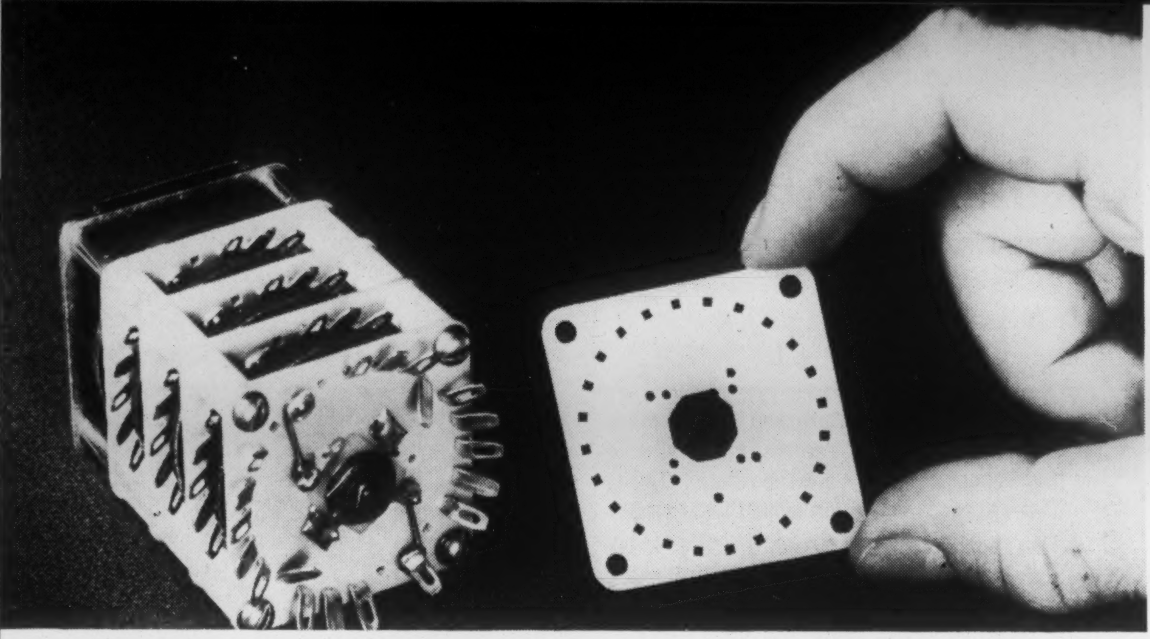
TABLE 6—PROPERTIES OF COMPOSITES
(See also page 150)

Binder	Material	Thickness, mils	Dielectric Strength, v/mil	Insulation Class	Max Operating Temperature, F
Conventional Varnish	Rag Paper (5 mils)—Varnished Cloth (7 mils)	—	750	A	220
	Rag Paper (10 mils)—Varnished Cloth (7 mils)	—	700	A	220
	Rag Paper (15 mils)—Varnished Cloth (10 mils)	—	450	A	220
	Fish Paper (5 mils)—Varnished Cloth (5 mils)	—	800	A	220
	Fish Paper (10 mils)—Varnished Cloth (7 mils)	—	750	A	220
	Fish Paper (15 mils)—Varnished Cloth (7 mils)	—	500	A	220
	Jap Paper—Mica Splittings—Jap Paper	3-6	300-500	A	220
	Rope Paper—Mica Splittings—Rope Paper	3-6	300-750	A	220
	Jap Paper—Mica Splittings—Fish Paper	10-12	300-500	A	220
	Jap Paper—Mica Splittings—Cotton Cloth	5.5-7.5	300-500	A	220
	Jap Paper—Mica Splittings—Rayon Cloth	5	300-500	A	220
	Jap Paper—Mica Splittings—Glass Cloth	5.5-8.0	300-500	A	220
Organic Varnish or Resin	Mica Splittings—Cellophane	5-15	—	A	220
	Mica Splittings—Glass Cloth	4-20	900-1000	B	265
	Glass Cloth—Mica Splittings—Glass Cloth	6-25	1000-1200	B	265
	Glass Cloth—Mica Paper—Glass Cloth	8-20	550-1000	B	265
	Polyester Film—Mica Paper—Polyester Film	5-20	700-1000	B	265
	Polyester Film—Mica Splittings—Polyester Film	4-20	1000-2000	B	265
Silicone Varnish	Mica Splittings—Glass Cloth	8-15	800-1000	H	500
	Glass Cloth—Mica Splittings—Glass Cloth	9.5-20 0	400-1300	H	500
	Polyester Film—Mica Splittings—Polyester Film	4-20	1000-2000	H	500
	Glass Cloth—Mica Paper	5-20	800	H	500
	Glass Cloth—Mica Paper—Glass Cloth	10-20	750	H	050

TABLE 7—PROPERTIES OF UNREINFORCED TAPES
(See also page 150)

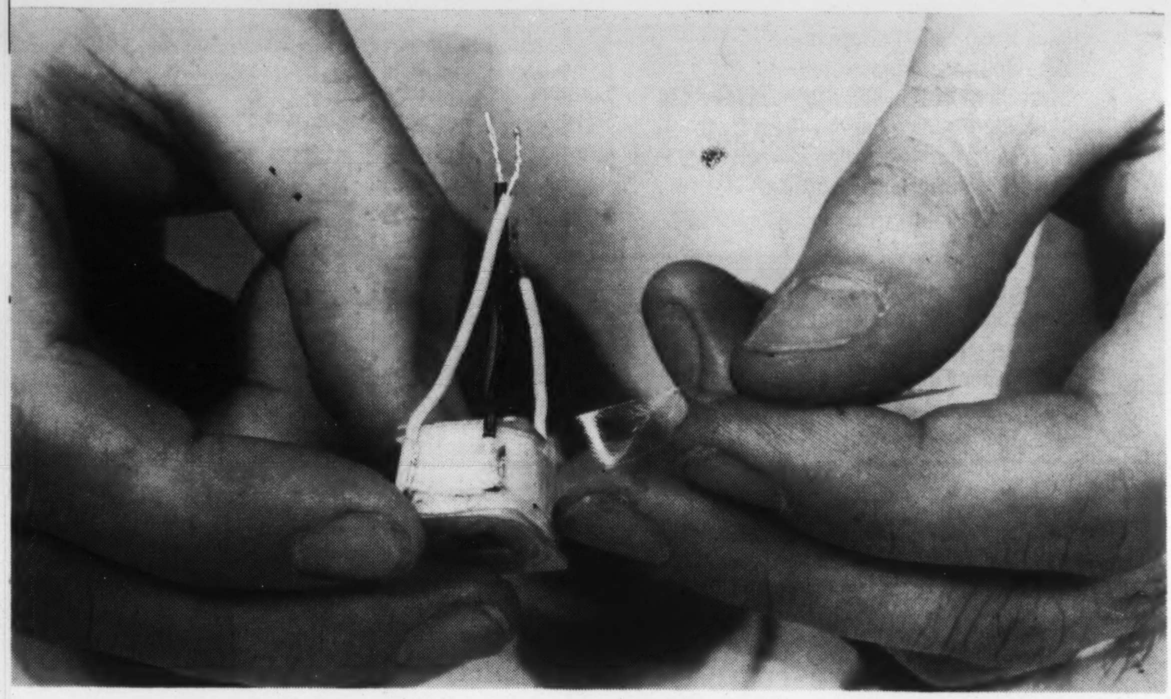
Type of Tape	Thickness, mils	Dielectric Strength, v/mil	Tensile Strength, lb/in. width	Tear Resistance	Insulation Class
Crepe Paper	10	125-200	15-30	Low	A
Flatback Paper	7	125-200	25-30	Fair	A
Cotton Cloth	11	150-250	40-90	Very good	A or O
Acetate Cloth	7-9	200-300	40	Fair	A or O
Glass Cloth (rubber adhesive)	6-8	200-500	140-200	Very good	B
Glass Cloth (silicone adhesive)	6-8	200-500	140-200	Very good	H
Acetate Film	2.0-3.5	1400-1600	15-30	Fair	A
Polyester Film	0.2-3	2000-7000	5-60	Excellent	A or B
Acetate-Rope Fiber	6-10	500-800	30-40	Fair	A
Acetate-Acetate Cloth	10	550-700	55-70	Fair	A or O
Ribbon Glass	1-3	3000[a]	—	—	C
Polytetrafluoroethylene	0.5-13	1000-4000	1-30	Excellent	B and H
Polytrifluorochlorothylene	2-10	2000-5000	10-50	Excellent	B
Polystyrene	0.4-10	1000-3000	5-120	Good	A or O
Vinyl Chloride	6-20	700-1500	20-60	Very good	A or O
Vinylidene Chloride	0.5-10	1000-1800	5-100	Very good	A or O
Ethyl Cellulose	3-10	800-3000	30-100	Good	A or O
Polyethylene	0.5-10	1000-5000	1-35	Excellent	A or O
Irradiated Polyethylene	2-10	1000-4000	5-25	—	A
Polyamide	1-10	800-1500	10-100	Good	A or O
Cellophane	1-4	—	10-30	Good	B
Cellulose Triacetate	1-10	—	10-150	Fair	A
Vinyl Chloride-Acetate	1-10	1000-1500	5-45	Very good	A or O

[a] Thickness of 1 mil.



National Vulcanized Fibre Co.

Glass-silicone laminate *with high resistance to heat and moisture forms plates in miniature rotary switch.*



Minnesota Mining and Mfg. Co.

Polyester backed insulating tape, *in thickness of only 3 mils, is designed for use in fine wire coils, transformers and other miniature components.*

TABLE 8—PROPERTIES OF REINFORCED TAPES
(See also page 150)

Type of Tape	Tensile Strength, lb/in. width	Dielectric Strength, v/mil[a]
Cellulose Acetate-Rayon	200	1400
Cellulose Acetate-Glass	325–500	1400
Polyester-Rayon	200	2000
Polyester-Nylon	80–90	2000
Vinyl-Glass	500	1600
Paper-Glass	240	100–200
Polyethylene-Glass	135	1200
Vinylidene Chloride-Glass	65	1200

[a] Average values for thickness of 3 mils.

tion are given in Table 10. For purposes of classification these materials can be arranged as follows:

Thermosetting plastics — Those plastics which generally soften only once under heat and do not soften on subsequent heating. This group of insulating materials includes phenolics, amines (ureas and melamines), anilines, polyesters (alkyds and allyls), silicones and organic cold molded materials.

Thermoplastics — Those materials that usually can be softened repeatedly by heating and made rigid again by cooling. This group includes cellulosics, acrylics (methyl methacrylate), styrenes (polystyrene, modified polystyrene and styrene copolymers), fluorocarbons (polytetrafluoroethylene and polytrifluorochloroethylene), vinyls (polyvinyl chloride, polyvinyl chloride-acetate and vinylidene chloride) and polyamides (nylon).

Filler materials used in molded insulators include short fibers, chopped fabrics, and granular or flake fillers such as wood flour, mica and diatomaceous earth.

Plastics Laminates

Plastics laminates consist of a reinforcing material impregnated with a thermosetting resin. The material is laminated in multiple layers, then cured with heat or pressure to form dense, hard sheets, tubing or rods with good mechanical properties. Although not common, an insulation laminate may contain two or more types of base material and two or more resins.

The base materials used are cellulose paper, cotton fabric and web, glass fabric and mat, asbestos paper and fabric, nylon, and occasionally Orlon. Wood veneers and insulating boards are sometimes impregnated or coated with various resins, also. The most common binders for laminated plastics are phenolics, melamines, epoxies, diallyl phthalates, polyesters, silicones and fluorocarbons. Significant properties of these laminates are given in Table 11. (Considerable supplementary data on electrical and mechanical properties of insulation laminates are contained in "Selecting Plastics Laminates for Industrial Use," M&M, Feb '57, pp 130-138).

Insulation laminates are easily machined and possess good strength and dimensional stability. Sheet sizes vary from 36 x 36 to 49 x 108 in. Tubing is produced in sizes ranging from 3/32 in. i.d. up to 72 in. o.d., in wall thicknesses from 0.0075 to 2 in. Round, square, rectangular, oval and irregular shapes are available. Molded rods are available in diameters from 3/32 to 4 in.

Vulcanized fibre is a dense material of partially regenerated cellulose made by treating paper with zinc chloride to obtain a gelled substance; the zinc chloride

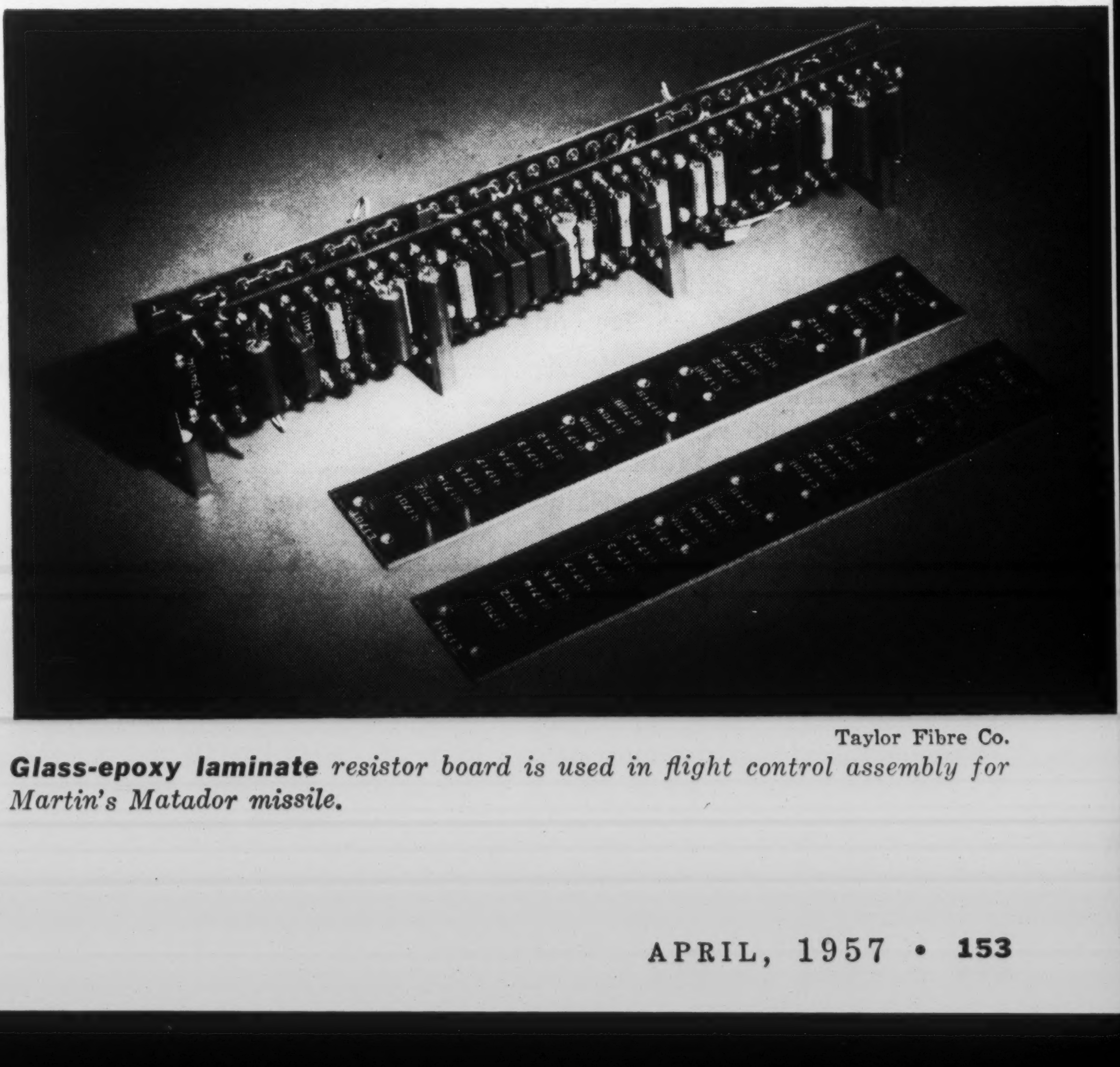
TABLE 9—PROPERTIES AND FORMS OF PLASTICS FILMS AND SHEETS
(See also page 151)

Type of Plastic	Forms	Thick-ness, mils	Width, in.	Tensile Strength, 1000 psi	Tear Strength, lb/in. width	Elonga-tion, %	Max Operating Tempera-ture, F	Brittle Tempera-ture, F	Dielectric Strength, v/mil
Polyvinyl Chloride	Sheets, rolls, tapes	1-10	54-84	1.5-5.5	110-500	150-500	150-200	-50	1200-1500
Polyvinyl Chloride-Acetate	Sheets, rolls, tapes, tubes	1-10	84	2.0-4.5	—	150-500	150-200	—	1000-1500
Vinylidene Chloride	Rolls	0.5-10	54	1.8-15	80-465	20-140	150-200	-25 to -50	1000-1800
Cellophane	Sheets, rolls, ribbon	0.9-1.7	45-56	4.5-18	—	15-45	300	—	—
Cellulose Acetate	Sheets, rolls, tubes	0.5-10	40-60	5.5-15	—	25-45	150-220	—	700-1200
Cellulose Triacetate	Sheets, rolls	1-10	40	9-16	—	10-40	300-400	—	—
Ethyl Cellulose	Sheets, rolls, tubes	3-10	28-29	7-11	—	30-40	200-250	—	800-3000
Polytetrafluoroethylene	Sheets, tapes, tubes	0.5-13	12	1.5-3.5	—	100-300	500	-130	1000-4000
Polytrifluorochloroethylene	Sheets, rolls, tapes, tubes	2-10	20	6.0-6.5	—	90-200	300	-80	2000-5000
Polystyrene	Sheets, rolls	0.4-10	40-43	7-12	275-500	3-10	175-200	—	1000-3000
Polyamide	Rolls	1-10	18	9	—	Orients	180-380	-60	800-1500
Polyester (polyethylene terephthalate)	Sheets, rolls, tapes	0.2-7.5	54	15-30	50-1750	35-110	300	-80	1000-7000
Polyethylene	Sheets, rolls, tapes, tubes	0.5-25	108	1.0-3.5	65-575	200-800	200	-70	1000-5000
Rubber Hydrochloride	Sheets, rolls, tapes	0.4-2.5	60	3.5-5.0	—	200-800	180-200	-20	—
Vinyl-Nitrile Rubber	Sheets, rolls, tapes, tubes	1-3	11.5-41.5	2.5-4.0	—	250-500	200	-32	—
Cellulose Acetate Butyrate	Sheets, rolls	1-10	40	4-10	—	40-100	120-180	—	800-1500

is removed by leaching, and the resulting product is dried and finished by calendering. Though vulcanized fibre is not actually a plastics laminate, some of its properties (see Table 11) and many of its uses are similar. Sheets up to 52 x 84 in. are available in some grades; thicknesses vary from 0.004 to 2 in. Tubing is produced in diameters from 1/8 to 16 in., in wall thicknesses from 0.020 to 1/2 in. Rod sizes vary from 3/32 to 2 in. dia.

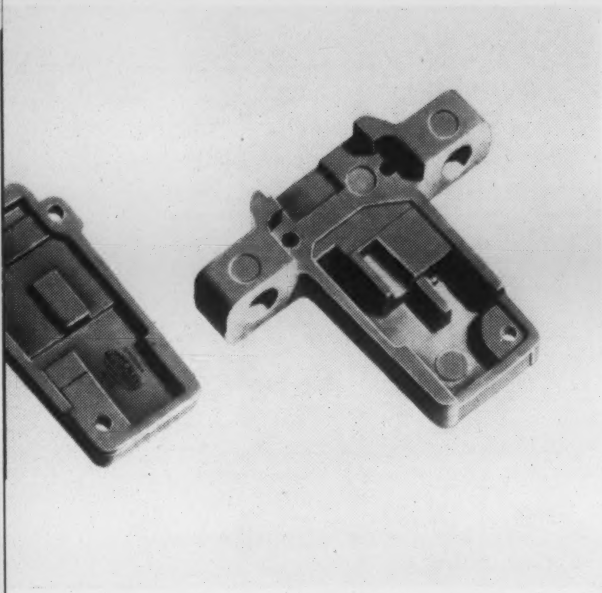
Pasted or Built-Up Mica

Because of the scarcity and high cost of sheet mica, mica is usually used in the built-up or paste form made by bonding flakes together with natural or synthetic resins or with inorganic



Taylor Fibre Co.

Glass-epoxy laminate *resistor board is used in flight control assembly for Martin's Matador missile.*



Mycalex Corp. of America

Glass-bonded mica, *selected for superior dimensional stability, forms case and cover of recording head unit for computer.*

TABLE 10—PROPERTIES

Type of Plastic	Mechanical Properties					
	Ten Str, 10^3 psi	Compr Str, 10^3 psi	Flex Str, 10^3 psi	Mod of Elas, 10^5 psi	Izod Impact Str, ft lb/in.	Rockwell Hardness
Ethyl Cellulose	2-8	10-35	4-12	1-3	2-8	R 50-115
Cellulose Acetate	2-9	13-36	2-16	0.9-4	0.4-5	R 35-125
Cellulose Acetate Butyrate	3-7	7-22	2-10	0.7-2	0.8-6	R 30-115
Methyl Methacrylate	7-9	12-18	13-17	4.5	0.4-0.5	M 85-105
Polystyrene	5-9	11-16	8-16	4-6	0.25-0.5	M 65-90
Modified Polystyrene	3-12	5-16	5-17	1.8-6	0.25-11	M 65-90
Styrene Copolymers	4-12	5-16	7-17	2-5	0.4-5	M 80-90
Polyethylene	1-6	—	—	0.2-0.6	—	R10
Polytrichlorofluoroethylene	6	32-80	8	2-3	3.5	R110-115
Polytetrafluoroethylene	1.5-3	1.7	—	0.6	3	—
Polyvinyl Chloride (rigid)	5-9	10-13	8-16	5-6	0.4-20	—
Polyvinyl Chloride Acetate	6-9	10-11	9-14	3.5-4	0.4-0.5	—
Vinylidene Chloride	3-5	2-3	4-6	0.5-0.8	0.3-1	M 50- 65
Polyamide	7-11	7-13	8-14	2.5-4	1.0	R110-118
Phenol-Formaldehyde						
Wood Flour Filler	6-9	23-36	8-12	8-12	0.3-0.6	M100-120
Asbestos Filler	4-9	15-35	7-15	10-25	0.3-3.5	M 95-115
Mica Filler	5-7	15-25	8-12	30-50	0.3-0.4	M100-110
Glass Fiber Filler	5-10	17-26	10-60	33	10-50	M 95-100
Fabric and Cord Filler	3-9	15-30	8-15	9-13	0.8-8	M 95-120
Urea-Formaldehyde						
Alpha Cellulose Filler	6-13	25-35	10-16	15	0.2-0.4	M115-120
Melamine-Formaldehyde						
Alpha Cellulose Filler	7-13	25-45	10-16	13	0.2-0.4	M110-125
Cotton Flock Filler	7-9	30-35	13	—	0.4-0.5	—
Asbestos Filler	5-7	30	9-11	16	0.3-0.4	M110
Macerated Fabric Filler	9-11	30-35	12-15	—	0.6-0.8	M120
Glass Fiber Filler	6-10	25-32	15-25	—	8-12	—
Alkyd						
Mineral Filler	3-4	18-25	7-10	15-25	0.30-0.35	—
Glass Fiber Filler	4-10	20-25	5-30	16-20	3-24	M70-120
Aniline-Formaldehyde	8-10	25-35	12-20	5-6	0.3	M115-120
Diallyl Phthalate						
Asbestos Filler	4.5	22.5	8	—	0.5	M99
Glass Fiber Filler	6	25	9	—	0.6	—
Synthetic Fiber Filler	4.5	30	7	—	0.8-1.0	—
Silicone						
Mineral Filler	25-45	15-25	6-8	—	0.25-0.4	M89
Glass Fiber Filler	40-50	9-15	9-15	—	3-15	M45

binders. Insulation using mica paper instead of mica flakes has also been developed.

The natural micas in use are muscovite or phlogopite (amber). It is expected that synthetic fluorphlogopite, bonded with inorganic binders for resistance to high temperatures, will become important in future applications.

Shellac is still used extensively as a binder; however, a superior insulation is obtained with polyester or alkyd resin binders of the glyptal type. Epoxy resin binders are also available. Silicone resin binders are generally used where high temperature resistance combined with good electrical properties is required.

Pasted mica is generally classified as follows (see Table 12 for electrical properties):

Molding plate—This material is made of about 75 to 82% mica and 18 to 25% binder—shellac or epoxy for Class B insulation and silicone for Class H. Sheet sizes run as large as 36 in. square, in thicknesses from 0.004 to 0.063 in. The sheets are only partially cured and curing is completed when the insulation is molded. Typical molded insulations include: commutator end rings, troughs, slots, spools, coil forms and tubes.

Segment plate—This material is generally made of 85 to 90% mica flakes or mica paper and 10 to 15% binder—shellac or epoxy for Class B insulation and silicone for Class H. The low binder content combined with a full cure helps to prevent slippage of the mica flakes. Standard sheets are 18 x 36 in. (12 x 12 in. for the silicone type), in thicknesses from 0.010 to 0.063 in. Sheets as thin as 0.004 in. are also available. Chief applications for the segment plate insulation are: commutator segments, flat insulating parts, barriers, washers and disks.

Heater plate—The organic type (Class B) of heater plate insula-

OF MOLDED PLASTICS
(See also page 151)

Electrical Properties							Physical Properties						
Diel Str (⅛ in.) v/mil	Resistivity (50%, R.H.) ohm-cm	Dielectric Constant		Dissipation Factor		Arc Resistance, sec	Spec Gr	Ther Cond, Btu/sq ft/hr/°f/ft	Coef of Ther Exp, per °F x 10^{-5}	Max Cont Service, Temp, F	Water Abs (24 hr), %	Machinability	Moldability
		60 cps	10^6 cps	60 cps	10^6 cps								
THERMOPLASTICS													
350-500	10^{12}-10^{14}	3.0-4.2	2.8-3.9	0.005-0.020	0.010-0.060	150-200	1.1-1.2	0.10-0.17	18-36	115-185	0.8-1.8	Good	Excellent
250-365	10^{10}-10^{13}	3.5-7.5	3.2-7.0	0.01-0.06	0.01-0.10	50-310	1.24-1.34	0.10-0.19	14-29	140-220	2.0-6.5	Good	Excellent
250-400	10^{10}-10^{12}	3.5-6.4	3.2-6.2	0.01-0.04	0.01-0.04	—	1.15-1.22	0.10-0.19	20-31	140-220	0.9-2.2	Good	Excellent
450-500	10^{15}	3.5-4.5	2.7-3.2	0.04-0.06	0.02-0.03	—	1.18-1.19	0.10-0.15	16	155-190	0.3-0.4	Excellent	Excellent
500-700	10^{17}-10^{19}	2.4-2.7	2.4-2.7	0.0001-0.0003	0.0001-0.0004	60-135	1.04-1.07	0.05-0.08	11-14	150-205	0.03-0.05	Fair	Excellent
300-600	10^{12}-10^{17}	2.4-4.8	2.4-3.8	0.0003-0.02	0.0004-0.02	20-135	0.98-1.11	0.02-0.07	5-38	140-200	0.05-0.55	Good	Good
400-700	10^{14}-10^{15}	2.5-3.4	2.5-3.1	0.006-0.010	0.006-0.010	80-150	1.01-1.10	0.07-0.12	11-18	200	0.2-0.5	Good	Good
400-700	10^{13}	2.2-2.3	2.2-2.3	0.0005	0.0005	135-235	0.92-0.95	0.19	29-32	212-250	0.02	Fair	Excellent
530	10^{18}	2.3	2.5	0.015	0.010	360	2.1	0.03	8-13	390	Nil	Excellent	Excellent
480	10^{16}	2.0	2.0	0.003	0.003	200	2.1-2.2	0.15	18	500	Nil	Excellent	Excellent
700-1000	10^{17}	3.4-3.6	2.9-3.0	0.012-0.020	0.006-0.014	60-80	1.35-1.55	0.07-0.17	9-11	130-160	0.1-0.4	Excellent	Excellent
425	10^{16}	3.2-3.3	3.0-3.1	0.007-0.010	0.018-0.019	60-80	1.33-1.43	0.10	13-34	120-130	0.10	Good	Excellent
350	10^{14}-10^{16}	4.5-6.0	3.0-4.0	0.03-0.45	0.05-0.08	—	1.65-1.72	0.07	34	160-200	0.1	Good	Excellent
375-475	10^{14}	4.1-4.6	3.4-3 5	0.014-0.040	0.03-0.04	130-140	1.09-1.14	0.13-0.14	18-27	270-300	0.4-1.5	Excellent	Excellent
THERMOSETTING PLASTICS													
200-425	10^{9}-10^{13}	5.0-9.0	4.0-7.0	0.05-0.30	0.03-0.07	Tracks	1.32-1.45	0.10-0.17	5-8	300-350	0.3-1.0	Fair	Excellent
100-350	10^{10}-10^{12}	10-75	5.0-7.0	0.25-0.50	0.10-0.50	Tracks	1.52-2.00	0.19-0.39	3-4	350-400	0.1-0.5	Poor	Fair
300-460	10^{12}-10^{14}	4.7-7.5	4.2-5.2	0.01-0.07	0.005-0.040	Tracks	1.75-1.92	0.24-0.34	4-5	250-300	0.01-0.10	Poor	Fair
140-370	10^{13}	7.1	4.6-6.6	0.03	0.02	60	1.75-1.95	—	3	350-450	0.1-1.2	Poor	Good
200-400	10^{11}-10^{12}	6.5-15.0	4.5-7.0	0.08-0.45	0.03-0.09	Tracks	1.36-1.43	0.10-0.17	2-7	250	0.05-2.00	Fair	Fair
300-400	10^{12}-10^{13}	7.0-9.5	6.4-6.9	0.035-0.040	0.028-0.032	100-150	1.47-1.52	0.17-0.24	5	170	0.4-0.8	Fair	Excellent
300-400	10^{12}-10^{14}	7.9-9.5	7.2-8.2	0.030-0.080	0.027-0.045	110-180	1.47-1.52	0.17-0.24	7	210	0.1-0.6	Fair	Excellent
300-330	—	—	—	—	—	110-150	1.50-1.55	—	—	250	0.2-0.3	Good	Good
350-400	10^{11}	6.4-10.2	6.1-6.7	0.07-0.17	0.041-0.050	120-140	1.70-2.00	0.31-0.41	4-8	250-400	0.10-0.15	Fair	Good
250-350	10^{9}-10^{10}	7.6-8.6	6.5-6.9	0.07-0.11	0.036	115-125	1.5	0.24	5	250	0.3-0.6	Good	Good
250-300	10^{12}	—	—	—	—	180	1.9-2.0	0.28	3	300-400	0.3-0.6	Good	Good
400	10^{14}	5.9-7.5	4.6-5.5	0.02-0.06	0.015-0.040	175-200	1.80-2.25	—	6	300-350	0.1-0.8	Fair	Excellent
150-400	10^{12}-10^{14}	5.2-6.0	4.0-4.5	0.023-0.024	0.015-0.020	100-180	1.70-2.0	0.19-0.29	2-5	300	0.1-0.2	Fair	Excellent
600-650	10^{16}-10^{17}	3.7-3.8	3.5-3.6	0.002	0.006-0.008	—	1.22-1.25	0.63	9-11	180-190	0.01-0.08	Good	Fair
380	10^{9}	—	4.5	—	0.06	138	1.65	—	—	450	0.15	Good	Excellent
350	10^{9}	—	4.0	—	0.009	125	1.59	—	—	430	0.10	Good	Excellent
360	10^{9}	—	3.4	—	0.01	115	1.24	—	—	430	0.08	Good	Excellent
400	10^{7}-10^{9}	4.0-5.0	3.7-5.0	0.003-0.013	0.003-0.006	250-420	1.65-2.00	0.09-0.10	9-11	480	0.2-0.5	Fair	Fair
200	10^{7}-10^{13}	4.0-5.0	3.6-4.6	0.005-0.007	0.004-0.006	220-350	1.68-2.00	0.09-0.10	14	480	0.1	Fair	Fair

tion is composed of 80 to 93 mica and 3 to 20% binder. The inorganic type (Class C) is made up of 88 mica and 12% binder; this type is used up to 1000 F and, if made with phlogopite mica, will withstand 1600 F. Chief applications of heater plate are in heating appliances such as flatirons, hair driers and waffle irons; in strip and space heaters; and other parts where high heat resistance is required, such as terminal insulation, switch support insulation and washers. Standard sheets range up to 18 x 36 in., in thicknesses from 0.004 to 0.063 in.

Flexible plate—This cold-forming type of flexible mica insulation may contain up to 35% of a binder which remains permanently plastic at room temperature. It meets Class B insulation requirements with an organic binder and Class H requirements with a silicone binder. The material is available in 36 x 36 in.

TABLE 11—PROPERTIES
(See also

Type of Laminate	Mechanical Properties							
	Ten Str, 10^3 psi	Compr Str, 10^3 psi	Flex Str, 10^3 psi	Mod of Elast, 10^5 psi	Izod Impact Str, ft-lb/in. notch	Rockwell Hardness	Machinability	Insul Res (96 hr, 90% R.H.) megohms
Phenol-Formaldehyde								
Paper Base	6-25	20-40	10-25	4-30	0.4-2.2	M70-120	Good	2-35 x 10^4
Cotton Fabric Base	9-16	30-45	15-30	3-15	1-10	M70-120	Good	5-10 x 10^3
Cotton Web Base	15	30-40	18-21	—	2.0-5.5	M100-110	Good	10-200
Nylon Fabric Base	5-10	—	10-22	3.5	2-8	M100	Good	3-100 x 10^4
Glass Fabric Base	10-40	40-60	20-40	10-20	3-16	M105-110	Fair	25-500
Asbestos Fabric Base	5-12	18-45	10-35	3-15	2-11	M70-110	Fair	—
Asbestos Paper Base	5-15	35-40	10-35	—	0.8-2.0	M100	Fair	—
Wood Base	15-30	10-20	25-40	35	4-8	M90-105	Good	0.3-335.0
Melamine-Formaldehyde								
Paper Base	10-25	30-50	15-20	—	0.3-1.5	M110-125	Fair	—
Cotton Fabric Base	9-13	30-45	15-20	10-20	1-2	M110-120	Good	—
Asbestos Paper or Fabric	6-12	25-50	17-25	—	0.8-4.0	M110-115	Fair	—
Glass Fabric Base	25-50	30-85	28-55	30-40	5-15	M105-130	Fair	—
Glass Mat Base	16	60	20-25	15	5	—	Fair	—
Diallyl Phthalate								
Glass Fabric Base	20-30	45	40-50	—	4-7	M120	Fair	—
Cotton Fabric Base	8-11	40	12-17	—	0.8-1.2	—	Good	—
Polyester								
Glass Fabric Base	40-50	30-60	50-60	10-30	20-35	M100-110	Fair	—
Glass Mat Base	15-25	30-50	20-35	10-20	10-25	M90-110	Good	5-50 x 10^3
Paper Base	6-15	20-25	12-25	8-12	—	—	Excellent	—
Silicone								
Glass Fabric Base	10-25	35-45	10-45	35-45	5-22	M100	Fair	1-3 x 10^5
Asbestos Fabric	—	40-50	12-16	40-50	6-9	—	Good	—
Polytetrafluoroethylene								
Glass Fabric Base	8-15	20	10-13	—	5-6	M60	Good	5-5000 x 10^3
Ceramic Fiber Base	1.5- 4	—	—	—	1.0-2.5	—	Fair to Good	1 x 10^7
Epoxy-Glass	30-50	50-90	45-80	25-35	6-16	M105-120	Good	1-6 x 10^5
Vulcanized Fibre	6-12	20-30	12-20	8-12	1-8	R50-100	Good	—
Lignin	5- 8	25-30	9-15	—	0.5-1.5	M90	Good	—

[a] Short time test
[b] ¼-in. thickness

sheets in thicknesses from 0.003 to 0.031 in., and is commonly used for armature slot liners, field coils and generator and transformer insulation.

Tubing—This form of mica insulation is made with alkyd, polyester or epoxy binders for Class B insulation, silicone binder for Class H, and inorganic binders for Class C. Tubes are available in round, square and rectangular shapes and are used for coil forms, transformer cores, stud insulators, grid rheostats and bushings. Sizes range from 3/16 to 4 in. i.d., 12 to 36 in. length and 1/64 to ¼ in. wall thickness.

TABLE 12—PROPERTIES OF PASTED MICA
(See also page 154)

Type	Dielectric Strength, v/mil	
	Short Time	Step-by-Step
Molding Plate	400–1300	250–1100
Segment Plate	600–1300	400–1100
Heater Plate	600–1200	400–1000
Flexible Plate	350–1000	200–800
Tubes	300–500	200–400

Ceramics

As indicated in Table 13, the number of ceramic materials available for electrical insulation is large. In general, these materials can be categorized as follows:

Porcelain—Conventional porcelain insulators are made from clay, quartz and feldspar. Parts are usually made by dry pressing, wet processing, casting or extruding, and fired above 2000 F. Dimensional tolerances are poor and machining after firing is difficult. Special porcelains containing high percentages of mullite, zircon, wollastonite, etc., are available.

Steatite—Steatite insulators are made from talc (hydrous magne-

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Electrical Properties							Physical Properties				
Vol Res, ohm-cm	Dielec Str (step-by-step, ⅛ in.), v/mil	Dielectric Constant		Dissipation Factor		Arc Resistance, sec	Spec Gr	Ther Cond, Btu/sq ft/hr/°F/ft	Coef of Ther Exp, per °F x 10^{-5}	Max Cont Svc Temp, F	Water Abs (24 hr), %
		60 cps	10^6 cps	60 cps	10^6 cps						
10^{10}-10^{13}	250-800	4.5-7.5	3.6-6.0	0.02-0.10	0.02-0.08	Tracks	1.30-1.40	0.04	3-5	225-250	0.3-9.0
10^{10}-10^{12}	150-450	5.0-10.0	5.0-5.7	0.04-0.20	0.05-0.10	Tracks	1.30-1.36	0.05-0.06	3-6	225-250	1.0-2.0
—	150	—	7.0	—	0.10	Tracks	1.30-1.37	—	2-3	225	1.5
10^{14}	300-425	3.7-4.2	3.5-3.9	0.01-0.02	0.015-0.040	5-40	1.15-1.20	—	7	165	0.20-0.35
—	250-700	—	3.7-6.0	0.01-0.02	0.01-0.03	Tracks	1.4-1.8	0.03-0.04	3-5	290	0.3-2.5
—	50-125	—	5.5-7.0	—	0.10-0.15	Tracks	1.6-1.8	0.11	3-5	275	0.3-2.5
—	120	—	5.2	—	0.12	Tracks	1.65-1.85	—	2-3	275	0.4-2.0
—	—	—	5	0.20	0.05	Tracks	1.3	—	—	150-200	2.5-11.0
—	200-450	—	6.4-8.5	—	0.035-0.050	—	1.40-1.55	—	—	200-250	1.0-2.0
—	100-250	7.0-8.3	6.2-10.0	0.040	0.03-0.10	120-145	1.35-1.50	—	1-3	200-250	1.0-2.0
—	50-125	—	8.0-9.5	—	0.10-0.22	—	1.75-1.85	—	—	225-275	1.0-5.0
—	150-350	—	6.9-9.0	—	0.010-0.025	175-190	1.8-2.0	—	1-2	300	1.0-2.5
—	300	—	6.5	—	0.040-0.080	180	1.80	—	—	300	1.5-3.0
—	500	4.3	4.1	0.013	0.015	150	1.65	—	—	300	0.12
—	300	5.1	4.8	0.015	0.018	130	1.38	—	—	—	0.60
—	—	—	—	—	—	80-120	1.5-2.1	—	—	300-400	0.3-0.9
10^{12}	200-450	4.0-4.7	4.0-4.7	0.005-0.025	0.007-0.020	80-120	1.5-1.8	—	—	300	0.3-1.0
10^{13}	400-600	3.0-4.2	3.0-4.2	0.10	0.03	25-75	1.2-1.5	—	6	220-250	1.5
—	150-250	3.7-3.4	3.7-4.3	0.0006-0.0050	0.0012-0.0050	150-250	1.6-1.9	0.02	1-2	400-500	0.2-0.7
—	50-100	—	—	—	—	—	1.75	—	—	500	1.0-1.5
10^{12}	250-300	2.7	2.7	0.0005	0.0006	160	2.2	0.02-0.05	—	480	0.02
10^{13}	—	2.5-2.7	2.4-2.5	0.002-0.003	0.001-0.003	190	1.9-2.2	—	7	500	0.5-2.0
—	300-600	4.2-6.5	4.5-5.3	0.003-0.015	0.015-0.025	15-130	1.7-1.9	—	—	300-360	0.05-0.25
—	150-250[a]	4.7	—	—	0.03-0.08	140	1.0-1.5	0.07-0.12	4	225	18-65
10^{12}	105[b]	6	—	0.11	—	135	1.35-1.45	—	—	150	2.5

sium silicate). They are shaped by the same methods used for porcelain. As with porcelains, tolerances are somewhat poor and machining of fired parts is difficult. A type of magnesium silicate known as forsterite is used for applications where parts must be sealed to metals, or where extremely low dielectric losses are required.

Pure oxides—These very refractory materials are more difficult to shape and fire than the other ceramic materials and possess comparatively high porosity. The oxides most commonly used (alone or in combination) are alumina, beryllia, zirconia, magnesia and thoria. Also, compressed (not sintered) magnesium oxide is sometimes used as an insulator in items such as tubular resistance heating elements.

Fluxed oxide bodies—The best known insulators in this category are the high alumina bodies which contain up to 98% alumina. The materials are abrasive, but possess excellent mechanical and electrical properties. Among many other applications, they have proved extremely valuable for aviation ignition systems.

Cordierite—Cordierite is a magnesium-aluminum-silicate and is characterized by excellent thermal endurance. The material is available in either porous, low porosity or vitrified form.

Lithia ceramics—Insulating materials in the lithia-alumina-silica system are especially noted for their low coefficient of thermal expansion. Coefficients vary from low positive to low negative values over a wide temperature range. For this reason, the materials are capable of withstanding repeated quenchings from 2000 F into water at room temperature.

Titania, and titanate ceramics—These materials are used principally where a high dielectric constant (up to 10,000 for some types) is required. They also possess a low dissipation factor.

Phosphate-bonded talc or mica—Talc or synthetic fluor-phogopite have been mixed with phosphoric acid to produce promising new ceramic insulations. The materials are formed by pressing and heating, and they are machinable. They are also capable of withstanding high temperatures. Electrical properties have not yet been fully evaluated but they appear to be good.

Glasses—Electrical glasses are available in a wide range of properties and materials—from low temperature glasses to vitreous silica. Glass shapes are largely produced by manipulating the glass while it is still viscous, although powdered glass may be compressed to shape and then sintered.

Ceramoplastics and Cold Molded Materials

Ceramoplastics, represented almost entirely by glass bonded micas, are unusual in that they are entirely inorganic yet they are molded in the same way (except for the higher temperatures) as organic plastics. Ceramoplastics can replace organic plastics insulations in those applications where the electrical, mechanical or thermal requirements are too severe for the organics or where dimensional stability or resistance to nuclear radiation is required.

The materials can be molded into complex shapes with extreme precision. Distortion and warpage are eliminated since, unlike conventional ceramics, ceramoplastics require no heat treatment after forming. Also, there is no cold flow after molding.

Ceramoplastics utilize special low temperature glasses as a binder. These glasses permit operation of the insulators at temperatures of 660 to 900 F, depending upon the type of glass and the percentage of mica in the filler. Filler materials consist of natural or synthetic mica in powdered form; titanates, quartz, glass fibers, alumina, etc. are added when special properties are required.

Since molding temperatures are comparatively low (about 1000 to 1500 F) it is possible to mold metal inserts directly into the insulators. This cannot be done with

TABLE 13—PROPERTIES
(See also

Property / Type	Steatite	Fluxed Alumina	Corderite	Titanate	Glasses		Forsterite
					Hard	Soft	
MECHANICAL PROPERTIES							
Tensile Strength, 1000 psi	6-10	20-25	2.5-4.0	4-10	6-10	5-9	8-10
Compressive Strength, 1000 psi	65-90	80-250	20-45	40-120	60-175	50-175	60-100
Flexural Strength, 1000 psi	16-24	20-45	8-12	10-42	11-16	10-15	18-20
Modulus of Elasticity, 10^5 psi	130-150	150-50	20-50	100-150	70-130	76-98	130-150
Charpy Impact Strength (½-in. rod), ft-lb	0.3-0.4	0.4	0.2-0.3	0.3-0.5	0.1-0.3	0.1-0.3	0.3-0.4
Knoop Hardness	1400	2000	1500	1800	250-900	250-900	1400
Water Absorption, %	0-1	Nil	0-15	Nil	Nil	Nil	Nil
Machinability	Poor	Poor	Poor	Poor	Poor	Poor	Poor
PHYSICAL AND THERMAL PROPERTIES							
Specific Gravity	2.5-2.7	3.2-3.6	2.1-2.4	4.0-8.9	2.2-2.7	2.4-4.3	2.7-2.9
Density, lb/cu in.	0.090-0.098	0.115-0.130	0.076-0.087	0.144-0.320	0.079-0.097	0.087-0.155	0.097-0.105
Ther Cond, Btu/sq ft/hr/°F/ft	0.85-1.45	1.69-12.10	0.73-0.97	1.94-2.90	0.36-0.73	0.36-0.73	1.21-2.42
Specific Heat, Btu/lb/°F	0.19-0.21	—	—	—	0.16-0.21	0.16-0.21	—
Coef of Ther Exp, per °F x 10^{-5}	1.55-1.89	0.99-1.44	0.36-0.54	1.26-1.80	0.14-0.90	1.17-2.16	1.98
Max Continuous Service Temp, F	1800-2000	2000-2700	2300	1800	800-1800	700-900	1800-2000
Thermal Shock Resistance	Moderate	Good	Good	Poor	Good to excellent	Poor to moderate	Poor
ELECTRICAL PROPERTIES							
Dielectric Strength (step-by-step, ¼ in.), v/mil	200-350	250-400	40-125	50-300	300-400	200-300	200-300
Volume Resistivity, ohm-cm	10^{13}-10^{15}	10^{14}-10^{15}	10^{12}-10^{14}	10^{8}-10^{15}	10^{15}-10^{17}	10^{12}-10^{17}	10^{13}-10^{15}
Dielectric Constant							
60 cps	5.9-6.5	8.4-8.5	—	14-9000	3.8-14.6	6.4-9.2	6.3
10^6 cps	5.2-6.3	8.3-8.4	4.5-5.4	14-8000	3.7-14.5	6.6-9.1	6.2
Dissipation Factor							
60 cps	0.0013-0.0150	0.0013-0.0015	—	0.0006-0.0360	0.0006-0.0008	0.0012-0.0800	0.0014
10^6 cps	0.0008-0.0035	0.0007-0.0010	0.004-0.012	0.0002-0.0105	0.0006-0.0050	0.0005-0.0100	0.0003
Arc Resistance, sec	500+	500+	High	High	High	Medium to high	High

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[a] Thickness of 9 mils.

conventional ceramics because of their high firing temperatures.

Compression molded ceramoplastics with a high mica content can be machined. Nearly all machining operations except punching can be performed within a tolerance of 0.001 in. or better. Slabs and rods can be purchased as stock items.

Cold molded materials have a base or filler that is usually asbestos, asbestos-silica or clay-asbestos. Bituminous or phenolic binders are used chiefly for organic insulations; these are cured at about 450 F. Binders for inorganic or refractory cold molded insulations may consist of portland cement, calcium hydrate or phosphoric acid.

Cold molded insulations are chiefly used for such applications as connector plugs, switch bases, sockets, outlet covers and fuse housings. Because of their high water absorption, the materials must often be impregnated.

Engineering properties of ceramoplastics and cold molded insulation materials are listed in Table 14.

Other Materials

Despite the inroads made by the newer organic and inorganic materials, a number of the older materials are still being used as electrical insulators.

Wood—Paraffinned or unwaxed maple wood wedges for motor slots are available in about 20 shapes and in more than 400 sizes. In addition to low initial cost, wood wedges are said to offer reduced assembly time and fewer breakdowns due to loose windings. Wood panels, usually of plywood, are also used to some extent for mounting instruments.

Paraffin-impregnated wood has a volume resistivity of 10^{10} to 10^{13} ohm-cm. Dielectric constant for untreated woods ranges from 1.4 to 2.9 and higher at 60 cps; dissipation factor ranges from 0.004 to 0.058.

Slate — Electrical slate, once widely used for panels and bases, has been largely supplanted by plastics, ceramics and ceramoplastics. The dielectric constant for this material varies from 12.4 to 19.0 at 1 mc and it may exceed 60 at 60 cps. The dissipation fac-

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Porcelain										
High Voltage	Low Voltage	Zircon	Lithia Porcelain	Alumina (sintered)	Beryllia (sintered)	Zirconia (sintered)	Muscovite Mica	Vitreous Silica (transparent)	Synthetic Mica	Wollastonite
10-15	6	3-8	1.5-3.5	15	10	12	5-10	—	—	—
25-100	25-50	80-150	60	225	100	200	30	150	—	80
9-15	3.5-6.0	20-35	8	48	20	27	—	10	—	20
70-140	70-100	200-300	120	470	430	260	200-300	97-104	—	—
0.2-0.3	0.2-0.3	0.4-0.5	0.25	—	—	—	—	—	—	—
1100	1100	1800	1400	2000	2000	1100	90	600	50-300	1400
0-0.05	0.5-2.0	Nil	0.1	10	0-1	8	Low	Nil	Low	0.03
Poor	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Fair	Poor
2.3-2.5	2.2-2.4	3.1-3.7	2.3	3.6	2.9	5.4	2.6-3.2	2.2	2.5-3.5	2.8
0.083-0.090	0.079-0.086	0.112-0.133	0.084	0.131	0.105	0.194	0.094-0.115	0.079	0.126	0.098
0.48-1.21	0.97-1.21	1.33-3.63	1.33	13.07	101 64	—	0.36	0.18	—	—
0.25	0.25	—	—	0.20	0.24	0.12	0.20	0.18	—	—
0.90-1.26	0.90-1.26	0.63-0.99	0.153	0.90-1.44	1.08	0.99	1.8	0.097	1.44-2.70	1.10
1800	1600	1800-2200	1800	3000	3500	3500	1000	2000	1300-1500	1500
Moderate	Moderate	Good	Excellent	Good	Excellent	Moderate	—	Excellent	—	Moderate
250-400	40-100	250-350	200-300	250	—	—	1000-2000[a]	250	—	265
10^{12}-10^{14}	10^{12}-10^{14}	10^{13}-10^{15}	—	10^{16}	10^{16}	—	10^{13}-10^{17}	10^{19}	10^{10}-10^{15}	—
6.5	5.5	9.1	—	—	—	—	5.4-8.7	3.8	—	—
5.4-7.0	5.0-7.0	7.1-9.0	5.6	9.6	5.8	—	5.4-8.7	3.8	5.9-7.8	6.2
0.0008-0.0009	0.015	0.036	—	—	—	—	0.0025	0.0007	—	—
0.0006-0.0100	0.010-0.020	0.0008-0.0014	0.005	0.0006	—	—	0.0001-0.0004	0.0001	0.0003-0.0010	0.0005
500+	500+	High	High	500+	500+	500+	High	500+	High	High

Corning Glass Works

Glass *is used as an insulator in a variety of electrical parts because of its excellent dielectric properties.*

tor is high—0.45 to 0.63 at 1 mc—and volume resistivity is about 10^8 ohm-cm.

Marble—This material is used to a minor extent for electrical insulation. Its volume resistivity is 10^9 to 10^{11} ohm-cm.

Amber—Amber is occasionally used for insulation. Significant electrical properties are: a dielectric constant of 2.70 at 60 cps and 2.65 at 10^6 cps; a dissipation factor of 0.001 at 60 cps and 0.006 at 10^6 cps; and a resistivity of 10^{16} ohm-cm.

Synthetic sapphire — Synthetic sapphires are single crystals available in the form of rods, balls, tubing and special shapes. The materials are used in equipment such as klystrons, magnetrons and traveling wave guides.

At 300 mc, parallel to the c-axis, the dielectric constant is 10.6 and the dissipation factor is less than 0.0001. Perpendicular to the c-axis the dielectric constant is 8.6 and the dissipation factor is also less than 0.0001.

At 100,000 mc, with the field perpendicular to the c-axis, the dielectric constant is 11.0 and the dissipation factor is 0.0002. Dielectric strength is high, and volume resistivity is 10^{11} ohm-cm at 930 F.

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TABLE 14—PROPERTIES OF CERAMOPLASTICS AND COLD MOLDED MATERIALS

(See also page 159)

Property / Material	Ceramoplastics (glass bonded micas)				Cold Molded Materials	
	Compression Types		Transfer Types		Organic	Refractory
	Insulation	Capacitor	Insulation	Capacitor		
PHYSICAL AND MECHANICAL PROPERTIES						
Specific Gravity	3.0	3.25	2.6-3.8	3.5-3.8	1.9-2.2	1.6-2.2
Density, lb/cu in.	0.11	0.115	0.075-0.136	0.125-0.136	0.068-0.077	0.058-0.073
Tensile Strength, 1000 psi	6-7	6	5-6	5	1.4-3.0	1.5-2.0
Compressive Strength, 1000 psi	35-42	35-42	20-25	20-25	6-15	12-18
Flexural Strength, 1000 psi	15-18	12-15	10-15	10-15	3.7-10.0	2.0-7.5
Modulus of Elasticity, 10^5 psi	90-120	90-120	70-80	70-80	—	—
Izod Impact Strength, ft-lb/in. notch	1.8	—	0.7	—	0.15	0.15
Rockwell Hardness	M110-120	—	M115-130	—	M75-95	M80-90
Water Absorption, %	Nil	Nil	Nil	Nil	1.0-5.5	3-15
Machinability	Fair to good	Fair to good	Poor	Poor	Poor	Good
Moldability	Fair	Fair	Good	Good	Poor	Good
THERMAL PROPERTIES						
Ther Cond, Btu/sq ft/hr/°F/ft	0.29	—	0.23-0.31	—	—	—
Specific Heat, Btu/lb/°F	0.16	—	0.13-0.24	—	—	—
Coef of Ther Exp, per °F x 10^{-5}	1.8	1.8	1.8-2.0	1.8-2.0	—	—
Max Continuous Service Temp, F	600-1000	600-700	500-800	500-600	500	900-1300
Heat Distortion Temp (264 psi), F	850	800	700	650	400+	400+
Thermal Shock Resistance	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
ELECTRICAL PROPERTIES						
Dielectric Strength (step-by-step, ¼ in.), v/mil	400-600	270-400	400-500	300-400	50-150	50-80
Volume Resistivity, ohm-cm	10^{14}-10^{15}	10^{14}	10^{14}-10^{17}	10^{14}	10^{12}	10^8-10^{10}
Dielectric Constant, 60 cps	7.5-7.6	—	7.0-9.5	—	17-28	—
Dielectric Constant 10^6 cps	7.4-7.9	10-25	6.9-9.2	10-40	6	—
Dissipation Factor, 60 cps	0.0035-0.0070	—	0.007-0.050	—	0.13-0.30	0.07
Dissipation Factor, 10^6 cps	0.0015-0.0020	0.0020-0.0040	0.0015-0.0120	0.0025-0.0035	—	—
Arc Resistance, sec	300	300	250	250	75-200	100-600

Reprints of this Manual are available at 35¢ each until supply is exhausted. See page 184 for complete list of available Manuals. Write for quotations on quantities of 100 or more. Address requests to Reader Service Dept., Materials & Methods, *430 Park Ave., New York 22, N. Y.*

FILE FACTS

Metal and Alloy Powders—A DIRECTORY[a]

Metal Powders

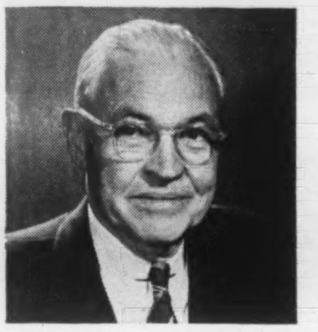
Production Method (or particle shape)	Mesh Size (approx)	Purity, %	Supplier
ALUMINUM			
(Roughly Spherical)	−5 and finer	99+ and 99.6+	A1
(Granulated roughly spherical)	0.25 in. dia.	99.0+ and 99.75+	A1
Atomization	5 microns avg to 25 microns avg	99.5+	A1
Mechanical stirring	−8 to +140	Grade I—95 to 97.5; II—92 to 95; III—90 to 92; IV—85 to 90	Ap
(Granular particles)	−8, −12+120, −120+200, −325	99	Be
——	——	99.3 to 99.99	M
——	−20, −30, −40, −100, −200	98 to 99	MD
Atomization	−24, −40, −100, −200	99.3	Mu
Atomization	−40, −100	——	R
Mechanical comminution	Various sizes	99	Rea
ANTIMONY			
——	——	99.5 to 99.9[a]	M
——	−100, −200, −325	99	MD
ARSENIC			
Resublimed under nitrogen	——	——	M
BERYLLIUM			
Mechanical Comminution	−200	98.5 min	BB
——	Various sizes	——	M
BISMUTH			
——	−100	99+	Be
——	−100, −200, −325	99	MD
CADMIUM			
——	−100	99+	Be
——	−150, −300	49.50 min	Ha
——	Various sizes	——	M
——	−100, −200, −325	99	MD
CHROMIUM			
——	−100	98	Be
——	−50	97 min	FM
Electrolytic	−100, −150, −250	Various grades: 99 to 99.75	Ha
Atomization	−28, −60, −100	99 min	Ha
——	Various sizes	——	M
Exothermic	−20 to −200	98.5 min	Mu
——	−50	98	SC
Electrolytic	−20, −100, −200, −325	99.8 min	UC
——	Various sizes	97.25 min	UC
COBALT			
——	−300	98 to 99	Be
——	1 to 3 microns	99.7 min	Ha
——	Various sizes	——	M
Hydrogen reduction	−100, −200, −300 or finer	97.5 min	Mu
COLUMBIUM			
——	20 to 80; −400	99.5 min	K
——	Various sizes	——	M
Hydride method	−325	99.3	MH
——	1 to 5 microns	99+	Mu
——	−80, −230, −325	99.7	SC
COPPER			
Electrolytic	Various sizes	99 to 99.5	AM
——	−150	99+	Be
Gaseous production	−40, −100, −200, −325	99.0 min	Gl
Atomization	Various sizes, 40% −325 to 95% −325	99.25 min	Gr
COPPER (cont.)			
——	Various sizes	——	M
——	−40, −150, −200	97.5 to 99	MD
(Dendritic)	−100	99.40 to 99.80	MM
Atomization	——	99.60	MM
(Spherical)	−100, −100+200	99+	NJ
Atomization (irregular or spherical)	Various sizes	99 min	PML
GOLD			
——	To specs	To specs	ES
——	——	——	M
IRON			
Carbonyl reduction	10 to 20 microns avg	99.5 to 99.9	An
Hydrogen reduction (sponge)	−30, −80	98.5 min (tentative)	AWS
——	−100+325	96 to 98	B
——	−100+325	96 to 98	Be
Sponge method	From −40 mesh up	97.5+	E
——	−30	94 min	EM
——	−80	98.5 min	EM
Electrolytic	−100, −200	99.0 min.	EM
Reduction (sponge method)	−40, −80, −100, −250, −325, 16 microns	98+	H
Magnetite	−40, −60, −100, −200	97.5+	H
Hydrogen reduction	−80, −200, −325	98.5 min.	Ha
Pulverization	−200, −100+325	93	Ha
Electrolytic (dense, oblong particles)	−65	99.3	HVA, J
Electrolytic (spongy particles)	−100	99.3	HVA, J
——	Various sizes	——	M
Carbonyl annealed	−325 (10 to 20 microns)	——	Ma
Reduction	−80, −100, −325	98+	Ma
Magnetite	−40	97.6 to 97.9	Ma
(Spherical)	−100	95.0 min	MP
(Spherical)	−100	95.5 min	MP
Reduced oxide	−100	98.50	Pl
Reduced oxide	−100	98.35	Pl
Electrolytic	−100	99.0 min	Pl
Hydrogen reduction	−100	96.6 min	Py
Electrolytic	−100	——	Py
Hydrogen reduction	−325	——	Py
Sponge method	−100	——	Fe
LEAD			
——	−100	99+	Be
Atomization	−40, −100, −200, −325	99.5 min	Gl
——	Various sizes	——	M
——	−100	99.5	MD
Atomization	——	99 min	PML
Atomization	−200	99.90+	NL
MAGNESIUM			
——	−100	93 to 95	Ha
Mechanical comminution	Various sizes	96 to 98	Rea
Mechanical comminution	Various sizes	——	U
MANGANESE			
——	−100	99.00	Ha
——	Various sizes	——	M
——	−100, −200, −325	99	MD
Alumino-thermic	−8, −100, −325	96 min	Mu
Electrolytic	−100	99.00 min	Pl
——	Various sizes	95.5 min	UC
Electrolytic	Various sizes	99.9 min	UC

◄ For more information, Circle No. 598

(continued on p 165)

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



Technical-ities

By John S. Davey

Factor of Safety—make it a reality

You can't calculate that with a bolt having yield strength of 4 times the working load you're automatically getting a *safety factor* of 4. Far from it. Only when the bolt is *tightened* to four times working load do you get it.

That's because rigidly fastened members can be externally loaded to the full value of residual tension in bolts without any separation or extra bolt stress.

Suppose you need a bolt for a 5000 lb. working load. For a X4 safety factor, you use a bolt of 20,000 lb. capacity, and tighten it to 20,000 lb. tension. If you tighten to only 10,000 lbs., any external load larger than this causes loosening, and progressive bolt failure from fatigue. So your safety factor is really only 2.

PRODUCTION MAN FOLLOW-THROUGH IMPORTANT

Factor of safety, then, is not established on the drawing board. It can only be put into the product by the shop man with wrench. In short, a bolt is no better than the supervision of its tightening.

A NOTE ON FLEXIBLE JOINTS

This case is different. You tighten such a joint just to working load. So use a bolt capable of this *plus* any added stress *multiplied* by your safety factor.

How to simplify bolt and nut usage

DESPITE their now unified dimensions, "standard" fasteners number thousands upon thousands of different types and sizes. More and more companies are beginning to realize that *usage* simplification offers advantages.

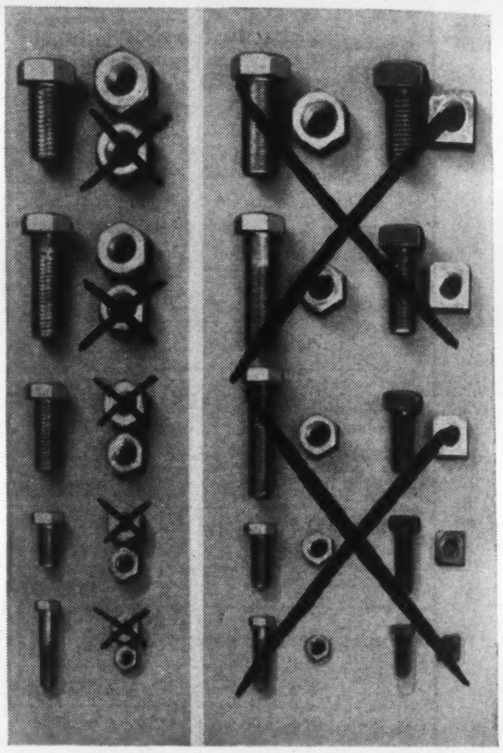
EXAMPLES

A well known electrical manufacturing company finds it no handicap to eliminate all $\frac{1}{16}$″ bolt sizes above $\frac{3}{8}$″, thereby simplifying production and purchasing.

One engineering firm eliminated 1700 different fastener items from inventory by determining that the jobs could be done as well by other sizes or types.

SOME SUGGESTIONS

To guide your thinking, RB&W points up the following ways to simplify: (1) Forget thread fits for all but specialized needs—standard "tolerance fits" have thoroughly proved themselves. (2) Why adhere to double thread standard when coarse threads prove stronger and assemble faster? (3) Stick with hex head bolts—they do better jobs than square. (4) It can save money to change diameter or length, rather than to add another item to stock. (5) Two standard physical grades meet most load range requirements—do you really need special alloys? (6) Heavy nuts really belong with larger size bolts—use finished nuts with the smaller sizes.



Here is a graphic display of possible simplification. From a typical array of fasteners, it shows what may be superfluous for meeting the requirements of proper fastening in a great many instances.

RB&W would be happy to enlarge on these facts, and help you simplify fastener selection to get proper joint strength and cut assembly time and inventory. Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N.Y.

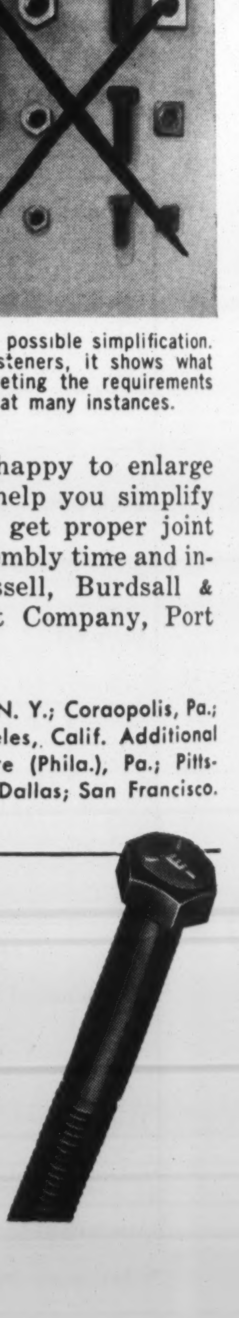
Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

High strength bolts save costly crane

At one company's plant, a large, heavy-duty crane had deteriorated due to rivets loosening. Replacing with new rivets was no permanent answer, but RB&W high tensile bolts were.

Used with hardened washers, these RB&W bolts clamp members together so tightly, no slipping into bearing takes place, holes are reinforced against fatigue, and connections become vibration-proof.

Assembling heavy duty equipment with RB&W high strength bolts in the first place can avoid such problems and create more satisfaction with the product.



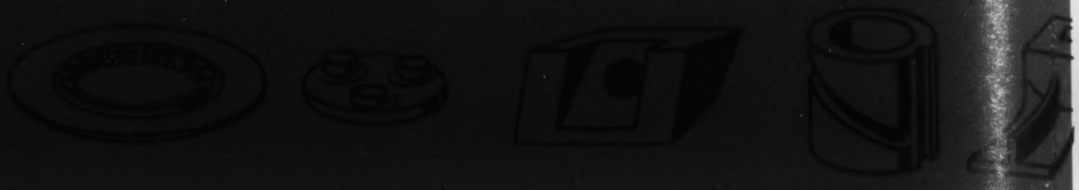
For more information, turn to Reader Service Card, Circle No. 374

Metal Powders—continued

Production Method (or particle shape)	Mesh Size (approx)	Purity, %	Supplier
MOLYBDENUM			
Hydrogen reduction	−200 (95% −325)	99.9	AEM
——	−100	99	Be
Hydrogen reduction	−80, −200	99.9	C
Hydrogen reduction	−30, −200	99.9	Fa
Hydrogen reduction	−200	99.75 min	Ha
——	−80	99.0 min	Ha
——	Various sizes	——	M
Hydrogen reduction	−80, −200	99.80 min	Mu
Hydrogen reduction	Up to 325	99.8+	NAP
Hydrogen reduction	−325 (1 to 5 microns)	99.80 min	S
——	−325 (1 to 5 microns)	99.50 min	S
——	−230	99.4	SC
——	−100	82 to 88	UC
NICKEL			
(Spherical)	−80, −150	99+	Be
(Irregular)	−200	99+	Be
——	−50	99.65	FM
(Spherical)	−100, −200, −325	99 min	Ha
——	Various sizes	——	M
——	−100, −150, −200, −325	99.25	MD
Electrolytic	−100	98.80 min	Pl
Hydrogen precipitation, (botryoidal particle shape)	Various sizes	99.5 min	SG
Hydrogen precipitation, (low density particles)	50 to 100% −325	99.5 min	SG
PALLADIUM			
——	To specs	To specs	ES
PLATINUM			
——	To specs	To specs	ES
——	−200	——	Ha
——	Various sizes	——	M
RARE METALS			
——	——	——	M
RHENIUM			
Hydrogen reduction (of $KReO_4$)	Various sizes	98.5	UT
Hydrogen reduction (of NH_4ReO_4)	Various sizes	Spectroscopically pure	UT
RHODIUM			
——	Various sizes	——	M
RUTHENIUM			
——	Various sizes	——	M
SELENIUM			
——	Various sizes	99.5 min	AM
——	−200	99+	Be
——	Various sizes	——	M
SILICON			
——	−100	97 min	Ha
——	Various sizes	——	M
——	Various sizes	96.5 to 98	UC
——	−30+80, −150+325, −325	99.7 to 99.9	UC
SILVER			
Electrolytic	Various sizes	——	AM
——	To specs	To specs	ES
——	−150, −250	999 fine	Ha
Galvanic precipitation	−60, −150, various sizes	999.0 fine	HH
SILVER (cont.)			
Chemical reduction	1 to 10 microns	99.76	HH
Atomization	−80	999.00 fine	HH
——	——	99.5 and 99.999	M
——	−100	99	MD
Atomization	——	99.9 min	PML
TANTALUM			
Electrolytic reduction	−80	——	Fa
——	−20	98.5 min	K
——	20 to 80	99.6	K
——	−325	99.5 min	K
——	−80, −200, −400	99.80	Ha
——	Various sizes	——	M
Hydride method	−200, −325	99.5	MH
——	−50, −325	99.5	SC
TELLURIUM			
——	——	——	M
THORIUM			
——	200 to 300 and finer	98.5 min	AEM
TIN			
Atomization	Various sizes	99.5+	AM
Atomization	−100	——	Be
Atomization	−40, −100, −200, −325	99.5 min	Gl
Atomization	Various sizes from 40% −325 to 95% −325	99.90 min	Gr
——	−100, −200	99.5 min	Ha
——	Various sizes	——	M
——	−50, −100, −200, −325	99.5	MD
Atomization	−100	99.85	NL
TITANIUM			
——	−100, −200, −325	99 min	Ha
——	Various sizes	——	M
——	−100, −200, −325	99.5	MD
Hydride method	−325	99+	Mu
——	−80	99.2	T
(Sponge-like shape)	−60 to −325	99+	UI
TUNGSTEN			
——	90% under 3 microns, peak at 2 microns	99.9+	AEM
——	−65	98.9 min	Be
Hydrogen reduction	−325 (various particle sizes available)	99.9	C
Hydrogen reduction	−200	99.9	Fa
——	−80	99 min	Ha
Hydrogen reduction	−325 or 1 to 5 microns	99.90 min	Ha
——	Various sizes	——	M
Hydrogen reduction	2 microns	99.6 min	Mu
——	−80	99 min	Mu
Hydrogen reduction	Up to 400	99.8+	NAP
Hydrogen reduction	−325 (5 size distributions in 1 to 5 micron range)	99.95	S
——	−65	99 min	UC
URANIUM (Presently available only with AEC approval)			
(Equiaxed regular shape)	Various sizes: −12 to −325	99.3 typical	SCN
VANADIUM			
——	——	——	M

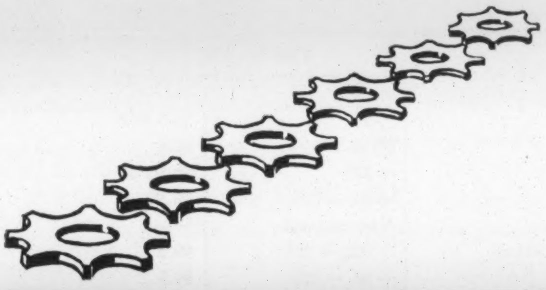
(continued on p 167)

IF YOU COMPACT AND SINTER

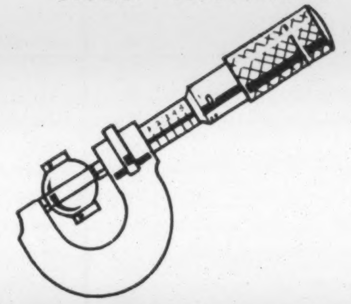


AND WANT

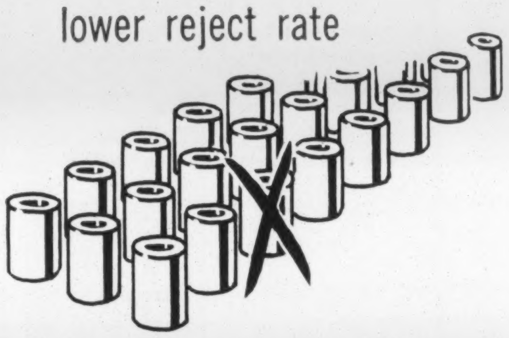
greater uniformity



closer tolerances



lower reject rate



USE

AMCO Quality Non-Ferrous Metal Powders

Blended to your precise specifications, AMCO quality metal powders can help you produce precision parts at lower costs. The rigid control of AMCO powder characteristics cuts reject rates and insures end products with

- **highest purity**
- **sharper, cleaner details**
- **better finishes**
- **extended storage life**

For complete details on AMCO metal powders, please contact the Metal Sales Department.

THE AMERICAN METAL COMPANY, LTD.

61 Broadway, New York 6, N. Y.

For more information, turn to Reader Service Card, Circle No. 415

Metal Powders—continued

Production Method (or particle shape)	Mesh size (approx)	Purity, %	Supplier
ZINC			
—	−35, −150	98.80 min	Ha
—	—	—	M
—	−200	98	MD
—	Various sizes: −20 to −200	98.80 min	NJ
Atomization	—	99.5 min	PML
ZIRCONIUM			
—	−150	94 and 99	FM
—	−250	99.50 min	Ha
—	—	—	M
Hydride method	−60, −325	95 to 98	MH

Alloy Powders

Production Method (or particle shape)	Mesh size (approx)	Composition and Purity, %	Supplier
ALUMINUM ALLOYS			
Mechanical comminution	Various sizes	50 Mg − 50 Al	Rea
BABBITT			
Atomization	−40, −100, −200, −325	99.5 min	Gl
BRASS			
Special process	−40, −100, −200, −325	99.5 min	Gl
(Spherical)	−28, −60, −100	50 to 90 Cu (some with 0.2 to 0.3 P)	Ha
—	−100	Various Cu-Zn compositions with several % Al or Pb	Ha
—	−100	85-5-5-5 (ASTM spec)	MD
—	−100	80-10-10 (ASTM spec)	MD
(Irregular)	−60, −100	Various compositions: 50 to 90 Cu; small % P, Pb, Al or Fe	NJ
Atomization (Irregular)	—	Various compositions: 60 to 90 Cu, small % P or Pb	PML
BRONZE			
Atomization	Various sizes	To specs	AM
Special process	−40, −100, −200, −325	99.5 min	Gl
Atomization	Various sizes, from 40% to 95% −325	To specs	Gr
Atomization	Various sizes, from 40% to 95% −325	Leaded (purity to specs)	Gr
—	−30+60	90 Cu − 10 Sn	Ha
—	−60+100, −100+325	90 Cu	Ha
—	−100	90 Cu − 10 Sn	MD
—	−100	Various compositions: 90 to 93 Cu, 5 to 10 Sn, 1.5 Zn added to ore grade	NJ
Atomization (spherical or irregular)	—	Various compositions: 50 to 90 Cu	PML
CHROMIUM ALLOYS			
(Irregular)	−20, −50, −100, −325 and micron size	Various compositions	AMP
—	−100	20 Cr − 80 Ni	Ha
—	—	Cr-Co; various compositions	Ha
Hydride method	−100	Cr-Co (30-70, 40-60, 70-30)	MH
Hydride method	−100, −150	Cr-Ni (80-20, 65-20, 50-50, 40-60, 20-80)	MH
—	−60	70 Cr − 30 Mo (99 purity)	SC
—	−60	Cr-W; 60 Cr (98.5 purity)	SC
COBALT ALLOYS			
(Irregular)	−20, −50, −100, −325 and micron size	—	AMP

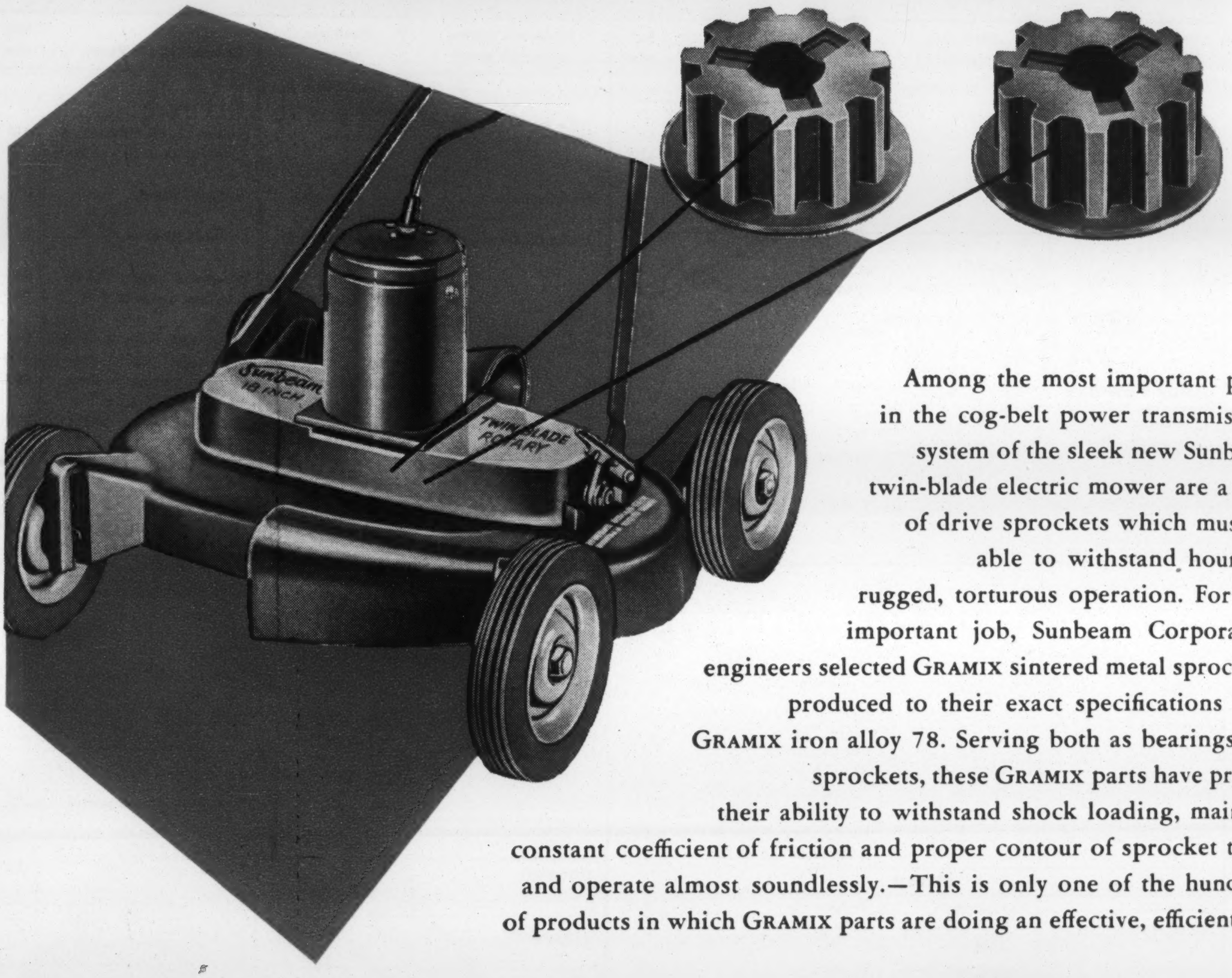
Alloy Powders—continued

Production Method (or particle shape)	Mesh size (approx)	Composition and Purity, %	Supplier
COPPER ALLOYS (See also Brass, Bronze, Nickel Silver)			
Atomization	Various sizes	Various Cu-Pb compositions, with up to 10 Sn and up to 4 Zn	AM
Special process	−30, −40, −60, −80	Cu-Sn (99.5 min)	Gl
Atomization	Various sizes; from 40 to 95% −325	Cu-Sn-Pb to specs	Gr
—	−100	Phosphorous copper (8.5 P)	Ha
—	−60, −100, −200	Beryllium copper (2, 3 or 4 Be)	Ha
—	—	Copper-coated iron (8 Cu-Fe)	Ha
—	−100	Cupro-nickel (ASTM specs)	MD
—	Various sizes: −10 to −150	Cu-Sn various compositions with 2.5 to 10.5 Sn	MD
—	−100	Phosphorous copper ASTM spec	MD
Atomization	—	Cu-Pb; various compositions	PML
IRON ALLOYS			
—	−20, −50, −100, −325 and micron size	—	AMP
—	Various sizes	Ni-Fe, Cr-Fe, Co-Fe and others	Ha
(Spherical)	−80	8 Cu, 3 Ni, bal Fe (96.0 min metallic)	MH
Atomization	—	Various compositions made to order	PML
Atomization (irregular)	−50, −100, −150, −200, −325	Si-Fe, Ni-Fe	V
MOLYBDENUM-CHROMIUM ALLOYS			
—	−60	70 Mo − 30 Cr (99 purity)	SC
NICKEL ALLOYS			
(Irregular)	−20, −50, −100, −325 and micron size	Various compositions	AMP
Atomization	−50, −100, −150, −200, −325	80 Ni − 20 Cr	V
NICKEL SILVER			
—	−200	64 Cu − 18 Zn − 18 Ni	Ha
—	−100	ASTM specs	MD
Atomization	−100	64 Cu − 18 Zn − 18 Ni and with 1.5 Pb	NJ
Atomization	−100	70 Cu − 20 Zn − 10 Ni	NJ
(Irregular)	−100	64 Cu − 18 Zn − 18 Ni, and with 1.5 Pb	NJ
(Irregular)	−100	70 Cu − 20 Zn − 10 Ni	NJ
Atomization	—	Various compositions made to order	PML
SILVER ALLOYS			
(Irregular)	−20, −50, −100, −325 and micron size	—	AMP
STEELS			
—	−150, −200	98.5 to 99 Fe	Be
Atomization	−40, −80, −325	98 Fe min	RS
		Stainless Steels	
Atomization (irregular)	−40+100, −40, −100, −200	—	H
(Irregular)	−100	Types 302, 302B, 316, 318 Si, 431	Ha
Atomization (irregular)	−50, −100, −150, −200, −325	Types 304, 316, 318, 347, 410, 431	V

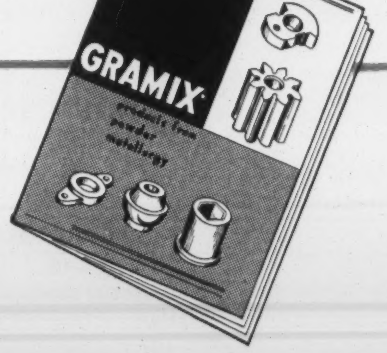
(continued on p 169)

for their new electrical mower Sunbeam engineers specify long wearing GRAMIX® iron sprockets

(PRODUCT OF POWDER METALLURGY)



Among the most important parts in the cog-belt power transmission system of the sleek new Sunbeam twin-blade electric mower are a pair of drive sprockets which must be able to withstand hours of rugged, torturous operation. For this important job, Sunbeam Corporation engineers selected GRAMIX sintered metal sprockets, produced to their exact specifications with GRAMIX iron alloy 78. Serving both as bearings and sprockets, these GRAMIX parts have proved their ability to withstand shock loading, maintain constant coefficient of friction and proper contour of sprocket teeth, and operate almost soundlessly.—This is only one of the hundreds of products in which GRAMIX parts are doing an effective, efficient job.



Write for this book. Being die-pressed to shape, then sintered, GRAMIX parts usually cost less than machined pieces . . . yet can be produced to tolerances as close as .0005 inch. GRAMIX Bulletin No. 21 tells the whole story. Write today for your copy.

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® • SINTERED METAL PARTS MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

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Alloy Powders—continued

Production Method (or particle shape)	Mesh size (approx)	Composition and Purity, %	Supplier
		STEELS continued	
		Alloy Steels	
(Irregular)	−20, −50, −100, −325 and micron size	Various types	AMP
——	——	Made to specs	H
——	——	4650, other AISI compositions	Ha
——	——	To specs	Pl
Atomization (irregular)	——	AISI/SAE 4630	V
		TIN-LEAD ALLOYS	
Atomization	−100, −150, −325 −100 and finer	Various compositions	AM
——	——	Various compositions	Be
Atomization	−40, −100, −200, −325	99.5 min	Gl
——	Various sizes	50 to 85 Pb, bal Sn	Ha

Alloy Powders—continued

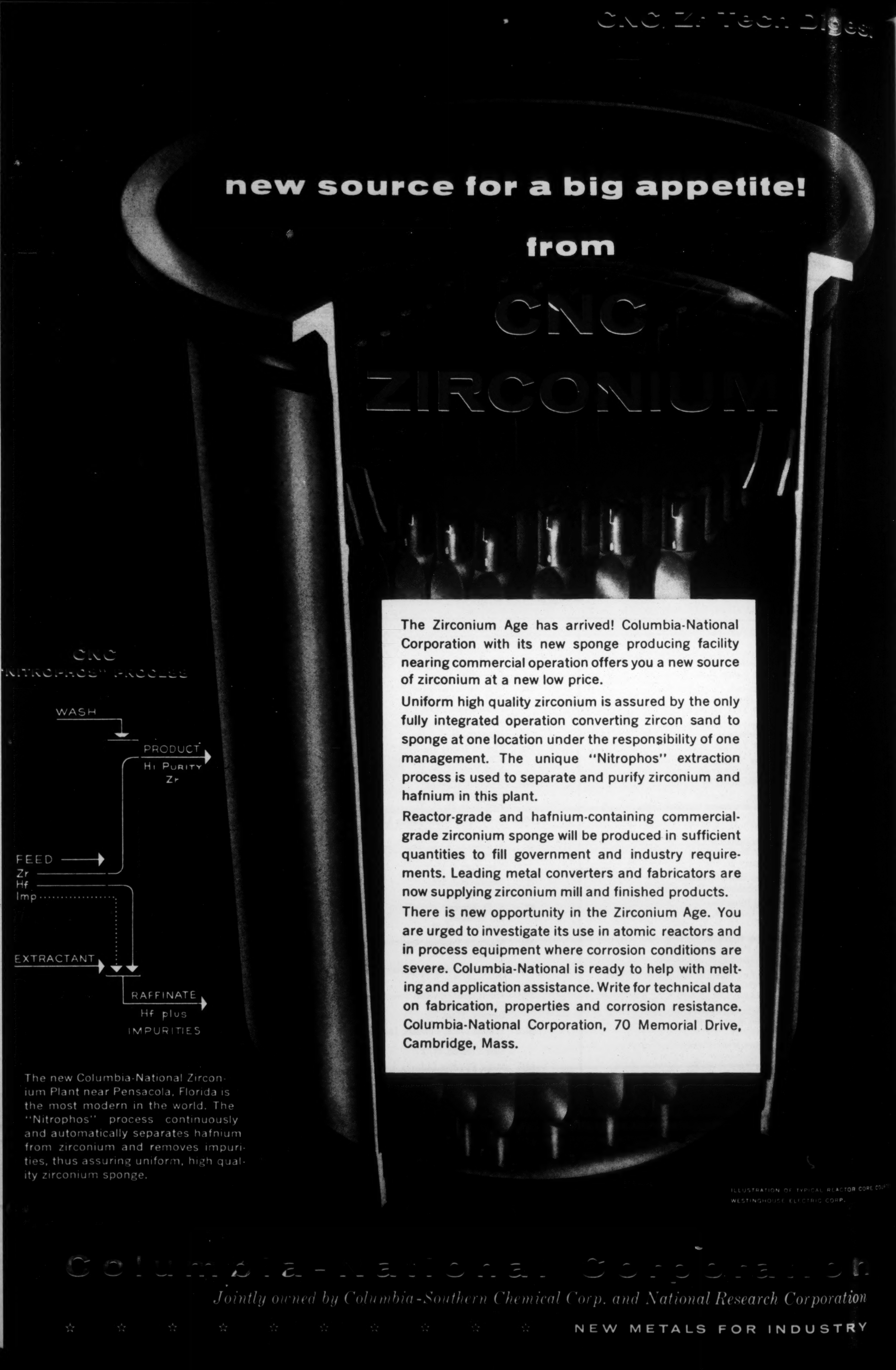
Production Method (or particle shape)	Mesh size (approx)	Composition and Purity, %	Supplier
		TIN-LEAD ALLOYS continued	
Atomization	−100	99.5 Sn + Pb	NL
Atomization	——	Various compositions	PML
		TITANIUM ALLOYS	
Hydride method	−325	Co-Ti (20-80, 50-50)	MH
Hydride method	−325	Ti-Ni (30-70, 50-50, 70-30)	MH
——	——	Ti-Fe; various compositions	NL
Comminution	−80, −100	Ti-Ni (approx 60 Ni)	NL
		ZIRCONIUM ALLOYS	
Hydride method	−325	Zr-Ni (30-70, 50-50, 70-30)	MH
Hydride method	−325	50 Zr − 50 Co	MH
		SPECIAL ALLOYS	
Various	Various	Made to order	AM, Ha, V, PML
Atomization	——	Made to order	

Suppliers and Their Addresses

Code Letter	
AEM	Associated Engineering and Mfg. Corp. Glen Ridge, N. J.
Al	Aluminum Co. of America 230 Park Ave. New York 17, N. Y.
AM	American Metal Co., Ltd. 61 Broadway New York, N. Y.
AMP	Alloy Metal Powders, Inc. 230-240 Eagle St. Brooklyn 22, N. Y.
An	Antara Chemicals Div. of General Dyestuff Corp. 435 Hudson St. New York 14, N. Y.
Ap	Apex Smelting Co. 2537 W. Taylor St. Chicago 12, Ill.
AWS	Allen Wood Steel Co. Conshohocken, Pa.
B	Paul Blum Co. 315 Larkin St. Buffalo 10, N. Y.
BB	Brush Beryllium Co. 4301 Perkins Ave. Cleveland 3, Ohio
Be	Belmont Smelting and Refining Works 330 Belmont Ave. Brooklyn 1, N. Y.
C	Cleveland Tungsten, Inc. 10200 Meech Ave. Cleveland 5, Ohio
EM	Easton Metal Powder Co. 233 Broadway New York 7, N. Y.
E	Ekstrand & Tholand 420 Lexington Ave. New York 17, N. Y.
ES	Eastern Smelting and Refining Corp. 107 W. Brookline St. Boston 18, Mass.
Fa	Fansteel Metallurgical Corp. North Chicago, Ill.
Fe	Ferrum Ltd. 506 Ste. Madeleine Blvd. Cap de la Madeleine Quebec, Canada
FM	Foote Mineral Co. 18 W. Chelten Ave. Philadelphia 44, Pa.
Gl	Glidden Co. Hammond, Ind.
Gr	Greenback Industries, Inc. 2527 W. Maple Rd. Birmingham, Mich.
H	Hoeganaes Sponge Iron Corp. Riverton, N. J.
Ha	Charles Hardy Inc. 420 Lexington Ave. New York 17, N. Y.
HH	Handy & Harman 82 Fulton St. New York 38, N. Y.
HVA	Husqvarna Vapenfabriks AB Huskvarna, Sweden
J	A. Johnson & Co., Inc. 21 West St. New York 6, N. Y.
K	Kennametal, Inc. Latrobe, Pa.
M	A. D. Mackay 198 Broadway New York, N. Y.
Ma	Magnetic Powders, Inc. Johnsonburg, Pa.
MD	Metals Disintegrating Co. Elizabeth (B), N. J.
MH	Metal Hydrides, Inc. 12 Congress St. Beverly, Mass.
MM	Malone Metal Powders, Inc. 220 W. 42nd St. New York 36, N. Y.
MP	Metal Powders Ltd. 73 Fifth Ave. Iberville, Quebec
Mu	Murex Ltd. Rainham Essex, England
NAP	North American Philips Co., Inc. Elmet Division Lewiston, Me.
NL	National Lead Co. Metal Div. 111 Broadway New York 6, N. Y.
NJ	New Jersey Zinc Sales Co. 160 Front St. New York 38, N. Y.
Pl	Plastic Metals Div. National Radiator Co. 342 Madison Ave. New York 17, N. Y.
PML	Powder Metallurgy Ltd. 59-62 High Holborn London WC1, England
Py	Pyron Corp. Box E, LaSalle Station Niagara Falls, N. Y.
R	Reynolds Metals Co. 2500 S. Third St. Louisville 1, Ky.
Rea	Reade Manufacturing Co., Inc. Metal Powder Div. 135 Hoboken Ave. Jersey City 2, N. J.
RS	Republic Steel Corp. Metal Powder Div. Landis Ave. Toledo 5, Ohio
S	Sylvania Electric Products, Inc. Tungsten & Chemical Div. P. O. Box No. 70 Towanda, Pa.
SC	Shieldalloy Corp. West Boulevard Newfield, N. J.
SCN	Sylvania-Corning Nuclear Corp. P. O. Box 59 Bayside, N. Y.
SG	Sherritt Gordon Mines Ltd. Chemical Metallurgical Div. Fort Saskatchewan Alberta, Canada
T	Titanium Metals Corp. of America 233 Broadway New York 7, N. Y.
U	U. S. Magnesium Co. Pleasant Valley, N. Y.
UC	Electro Metallurgical Co. Div. of Union Carbide & Carbon Corp. 30 E. 42nd St. New York 17, N. Y.
UI	United International Research, Inc. 38-15 30th Street Long Island City 1, N. Y.
UT	Dept. of Chemistry University of Tennessee Knoxville, Tenn.
V	Vanadium-Alloys Steel Co. Latrobe, Pa.

[a] **Many of the companies listed make special mesh size distributions or special alloy compositions to order.**

Compiled by Herbert B. Michaelson, International Business Machines Corp.


CNC Zr Tech Digest

new source for a big appetite!

from

CNC ZIRCONIUM

The Zirconium Age has arrived! Columbia-National Corporation with its new sponge producing facility nearing commercial operation offers you a new source of zirconium at a new low price.

Uniform high quality zirconium is assured by the only fully integrated operation converting zircon sand to sponge at one location under the responsibility of one management. The unique "Nitrophos" extraction process is used to separate and purify zirconium and hafnium in this plant.

Reactor-grade and hafnium-containing commercial-grade zirconium sponge will be produced in sufficient quantities to fill government and industry requirements. Leading metal converters and fabricators are now supplying zirconium mill and finished products.

There is new opportunity in the Zirconium Age. You are urged to investigate its use in atomic reactors and in process equipment where corrosion conditions are severe. Columbia-National is ready to help with melting and application assistance. Write for technical data on fabrication, properties and corrosion resistance. Columbia-National Corporation, 70 Memorial Drive, Cambridge, Mass.

The new Columbia-National Zirconium Plant near Pensacola, Florida is the most modern in the world. The "Nitrophos" process continuously and automatically separates hafnium from zirconium and removes impurities, thus assuring uniform, high quality zirconium sponge.

ILLUSTRATION OF TYPICAL REACTOR CORE COURT
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Columbia-National Corporation

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☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ NEW METALS FOR INDUSTRY

What's new IN MATERIALS

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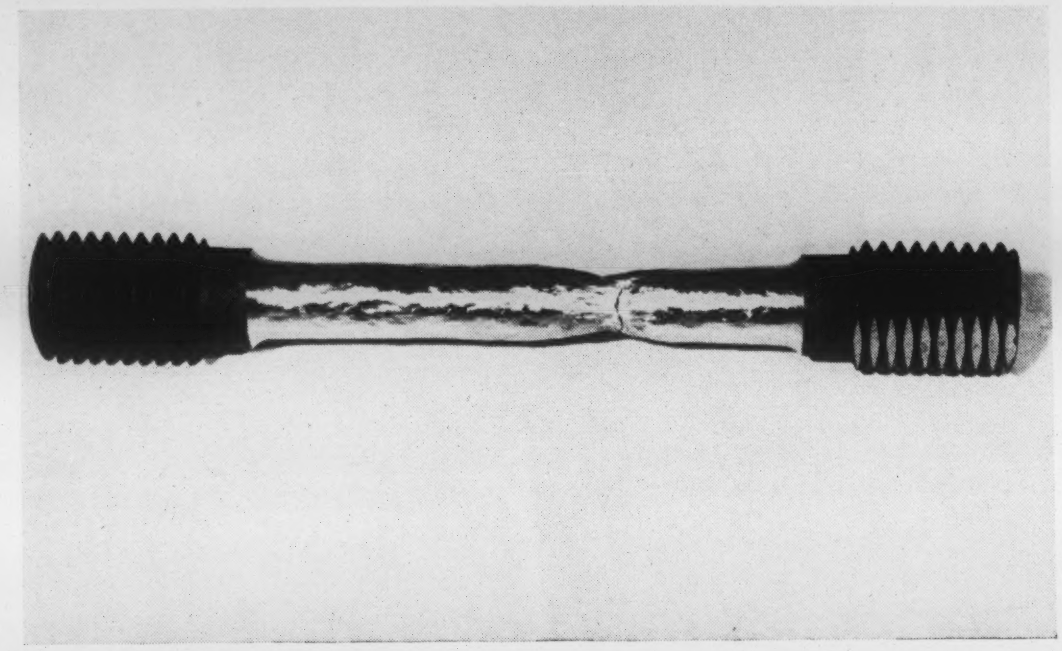


***High ductility** of CD-4MCu corrosion resistant cast alloy is shown by this pulled tensile specimen.*

Relatively low nickel content but . . .

Cast Stainless Alloy Is Stronger, More Resistant Than 18-8

■ A new high strength, cast stainless alloy combines excellent mechanical properties with excellent corrosion resistance. Developed in Ohio State University's Corrosion Research Laboratories as part of the research program of the Alloy Casting Institute, the new material represents substantial progress in the search for high strength, corrosion resistant alloys.

Although many stainless materials have been developed that exhibit high strength and hardness, some of them have inferior corrosion resistance as compared to regular 18-8 stainless. What makes the development of the new alloy (designated CD-4MCu) significant is that it not only possesses better mechanical properties than 18-8 but also has better corrosion resistance. Moreover, as shown in the accompanying table, the new alloy uses relatively little nickel.

According to Dr. M. G. Fontana, chairman of Ohio State University's Metallurgical Engineering Dept., not only is the corrosion rate of the new alloy very low but there is no tendency for the corrosion rate to increase with time. As a result, manufacturers of valves, pumps, fittings, high pressure components, etc., "can be assured that there will be no loss of corrosion resistance over a long period of time."

Part of the testing procedure to determine corrosion resistance of the new alloy, involved bending specimens after exposure to a boiling copper sulfate-sulfuric acid solution. No decrease in angle of bend before cracking was observed after exposure for 72 hr. In other tests, the new alloy showed no corrosion at room temperature in 10% sulfuric acid, 50% sulfuric acid or 0.5% hydrochloric acid; even in 5% hydrochloric acid the corrosion rate was only 60 mils per year.

In addition to better corrosion resistance, the new alloy is reported to have better machinability than 18-8 stainless, good welding and grinding characteristics, and good foundry characteristics (fluidity and feeding).

PROPERTIES OF CD-4MCu

Heat Treatment		Tensile Strength, psi	Yield Strength, psi	Elongation, %	Reduction of Area, %	Brinell Hardness	Charpy V Notch, ft-lb	Corrosion Rate, mils/yr[c]
Temp, F	Time, hr							
850	4[a]	141,000	100,000	25	38	302	9.5	6.5
950	3[b]	140,000	120,000	16	—	321	—	6[d]
1950	2 (w.q.)	113,000	81,000	29	48	248	104	6
As cast		121,000	84,000	27	41	262	19	18
2050	1 (w.q.)	103,000	85,000	19	—	250	—	7[d]

[a] Aging treatment preceded by water quenching after 2 hr at 1950 F.

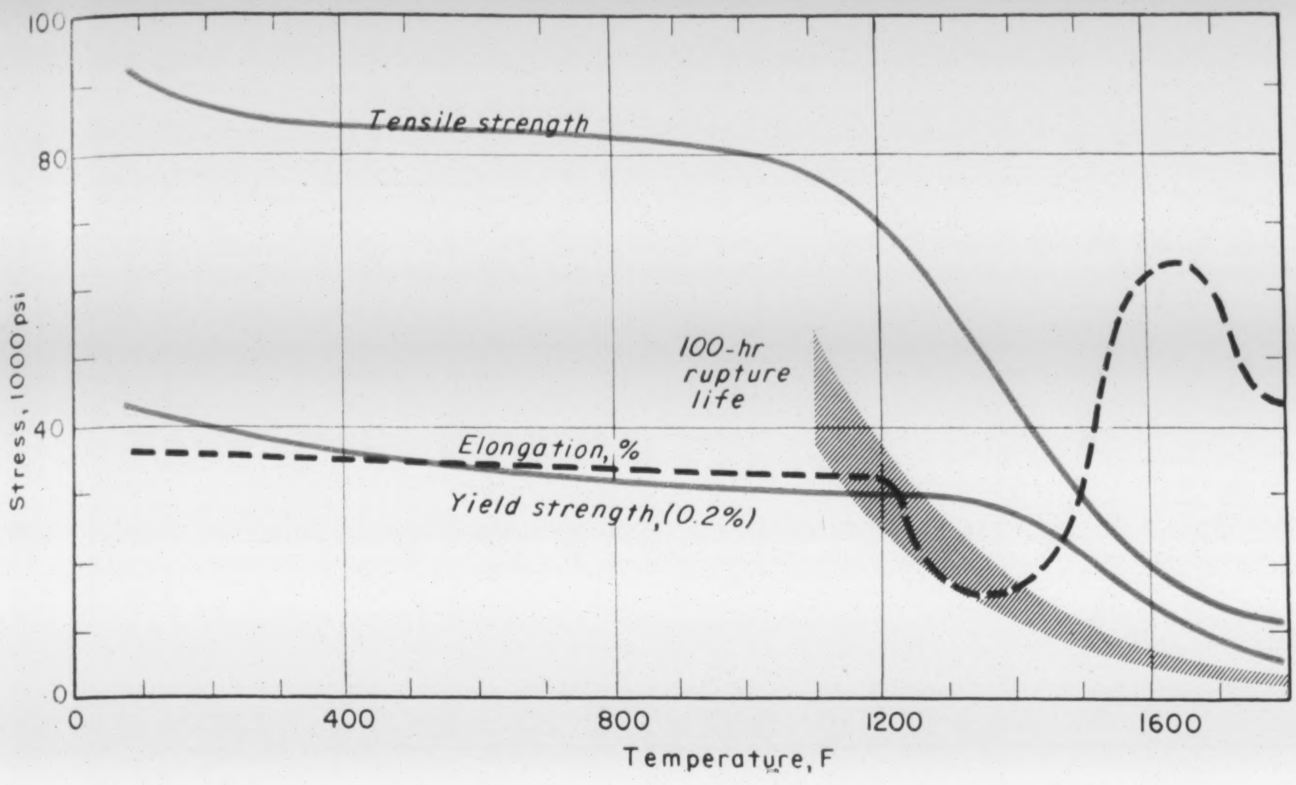
[b] Aging treatment preceded by water quenching after 1 hr at 2050 F.

[c] In boiling 65% nitric acid. Average of five 48-hr periods; two specimens each.

[d] Average of two 48-hr periods; single specimens.

COMPOSITION OF CD-4MCu, %

Chromium	25-27
Nickel	4.75-6.00
Carbon	0.04 max
Molybdenum	1.75-2.25
Copper	2.75-3.25
Silicon	1.0 max
Manganese	1.0 max
Iron	bal



Tensile and rupture *properties of Incoloy T.*

Improved Nickel Alloy Sheet Can Be Used up to 1600 F

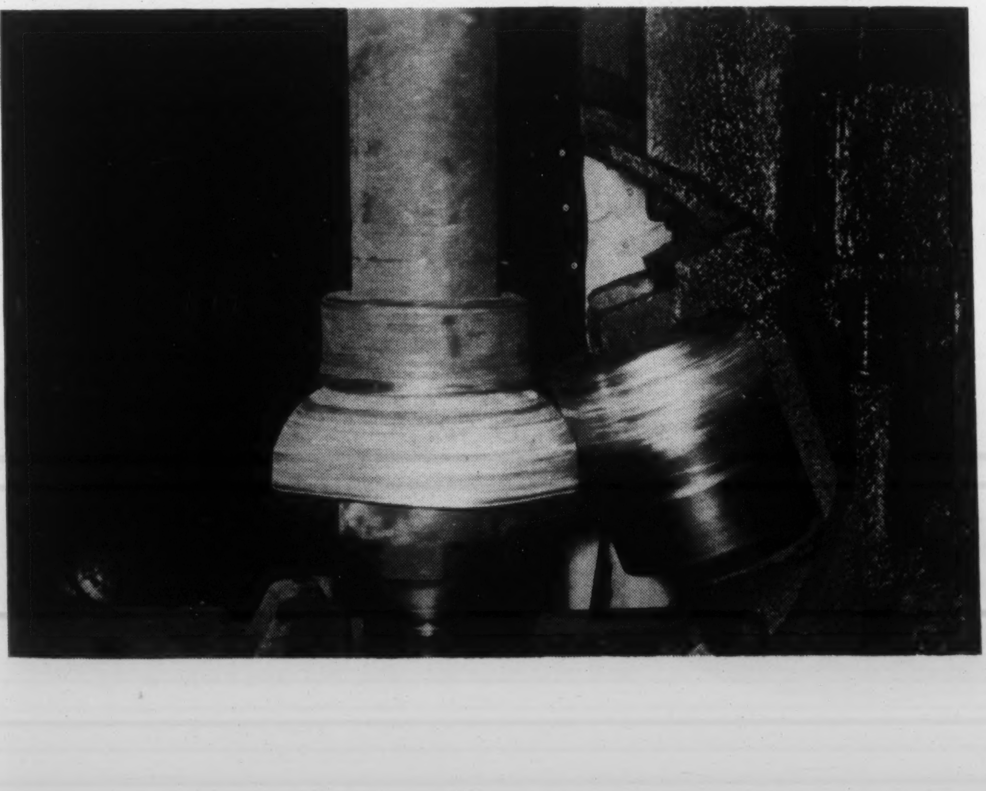
■ A high temperature alloy sheet material, developed by International Nickel Co., Inc., New York, N. Y., is expected to find wide use in highly stressed parts of jet engine combustion systems and in airframes used for hypersonic flight.

The new alloy, called Incoloy T, differs from the conventional Incoloy nickel-chromium-iron alloy in that it contains approximately 1% titanium. As a result of the titanium addition, the alloy exhibits improved tensile and rupture properties and has excellent oxidation resistance up to 1600-1700 F. Cyclic oxidation tests conducted on the alloy at 1600 F for periods from 100 to 1000 hr showed that although the material gains in weight the oxide layer that is formed adheres tightly to the surface.

The alloy sheet is designed to operate at temperatures up to 1600 F. It is generally annealed at 1900 to 1950 F. However, successful annealing has been accomplished by heating 20-30 min at 1800 to 1850 F, followed by rapid cooling in air. For use at temperatures below 1200 F, tensile and rupture strengths can be improved by cold working.

COMPOSITION OF INCOLOY T, %

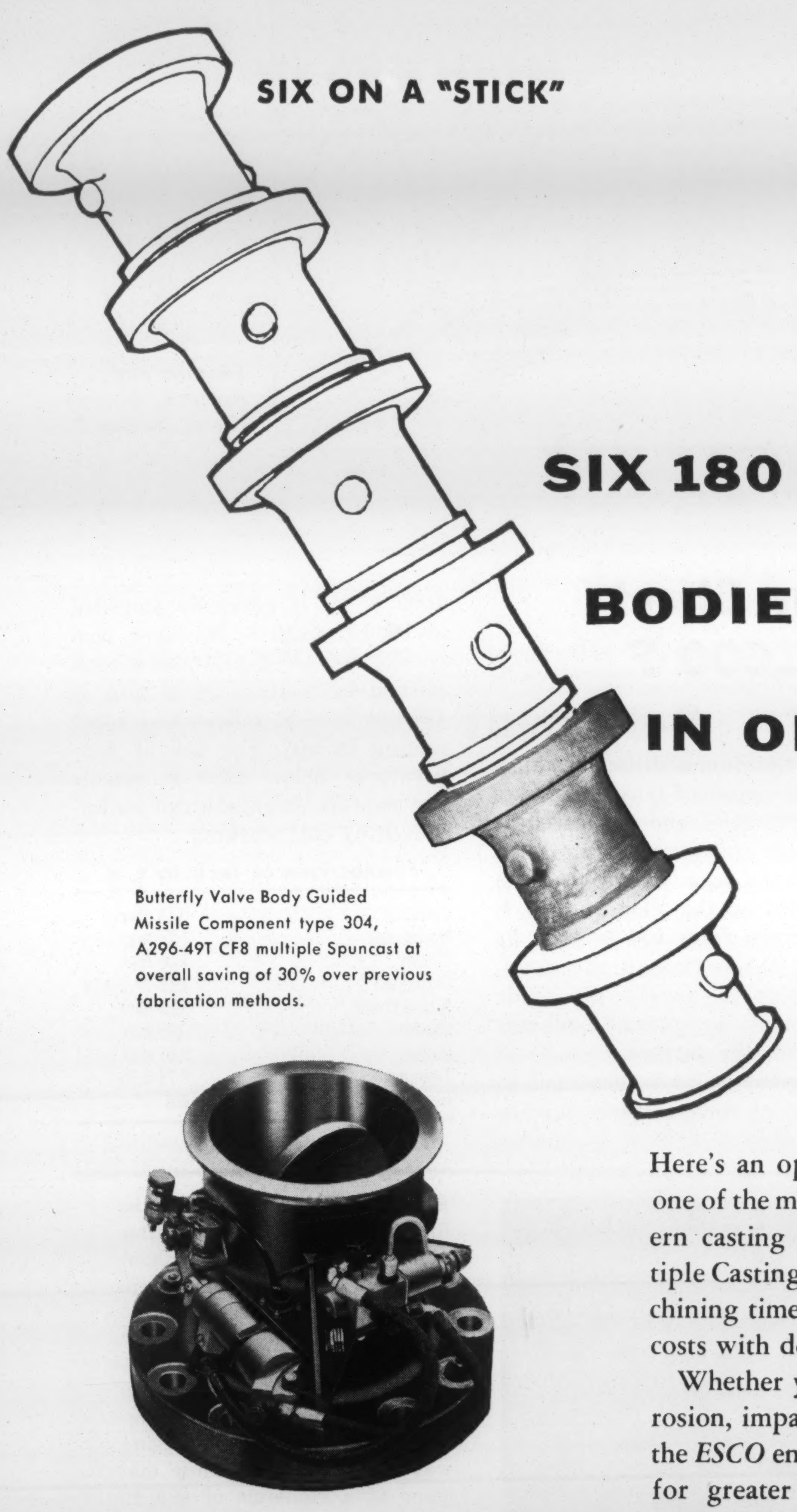
Carbon	0.10 max
Manganese	1.50 max
Silicon	1.00 max
Chromium	19.0-22.0 max
Nickel Cobalt	30.0-34.0
Copper	0.50 max
Sulfur	0.03 max
Titanium	0.75-1.50
Iron	bal



Spinning titanium—For the first time a "head" of solid titanium has been formed without the use of costly dies and stamping equipment, according to Lukens Steel Co.

In a research program conducted jointly by Lukens and Rem-Cru Titanium, Inc., a commercially pure titanium plate was worked on a spinning machine at a minimum of 600 F. (The plate had been previously heated under close temperature control at 1400-1450 F.) An elliptical-shaped head 16-in. in dia and ¼ in. thick was successfully spun on the standard equipment shown at the left.

(more What's New on p 175)



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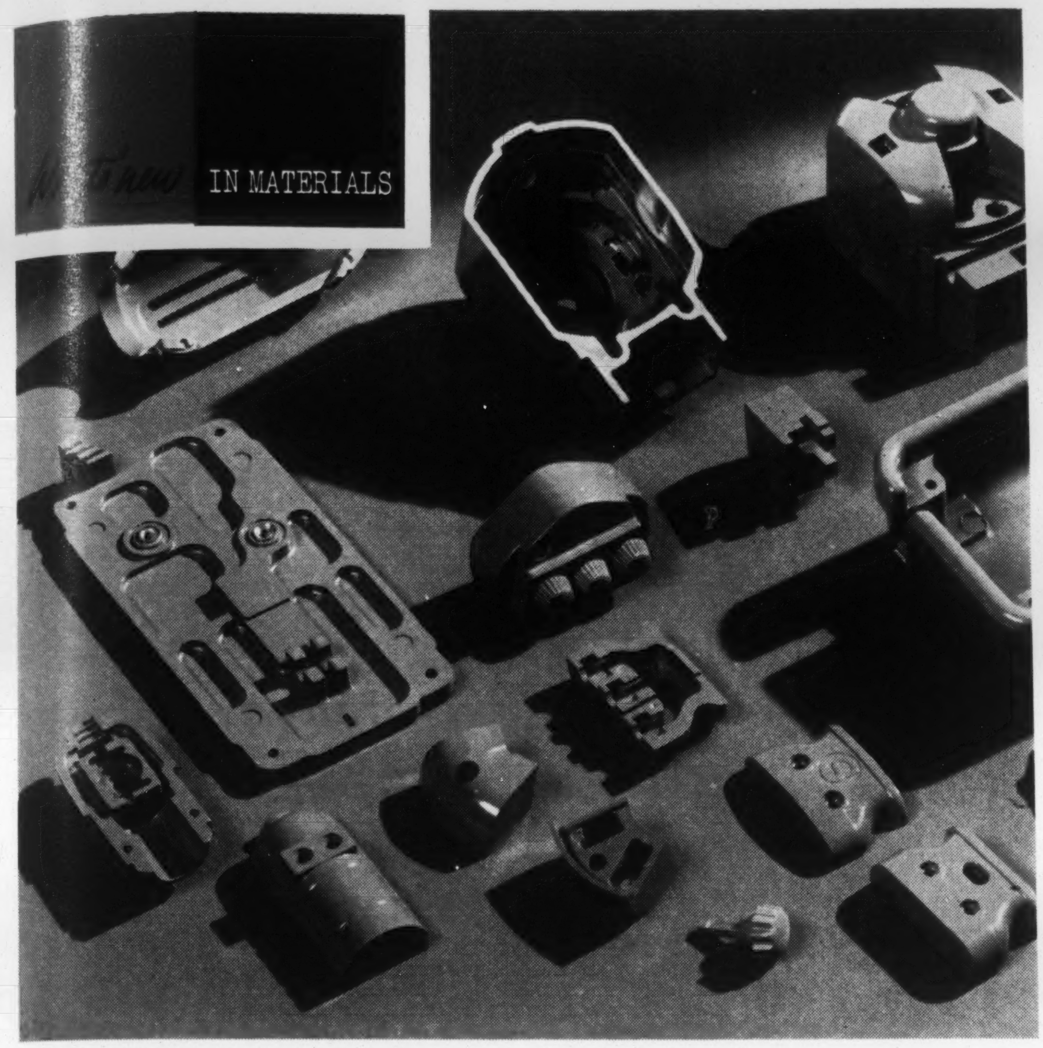


Sewing ***machine parts*** *molded of new polyester compound.*

TYPICAL PROPERTIES OF DUREZ POLYESTER MOLDING COMPOUND

PHYSICAL PROPERTIES	
Specific Gravity	1.79
Tensile Strength, psi[b]	5000
Izod Impact Strength, ft-lb/in.[b]	0.28
Flexural Strength, psi[b]	8500
Max Water Absorption, %	0.5
Compressive Strength, psi [b]	22,000
Molding Shrinkage, in./in.[a]	0.008
Heat Distortion (264 psi), F	360
Mod of Elasticity in Tension, 10^6 psi[b]	1.1
Rockwell Hardness[a]	M105
ELECTRICAL PROPERTIES	
Dielectric Strength, v/mil[c]	
Short-Time	400
Step-by-Step	324
Volume Resistivity, ohm-cm[b]	5×10^{14}
Dissipation (power) Factor[b]	
60 cps	0.011
1 kc	0.011
1 mc	0.022
Dielectric Constant[b]	
60 cps	4.6
1 kc	4.6
1 mc	4.4
Arc Resistance, sec	125

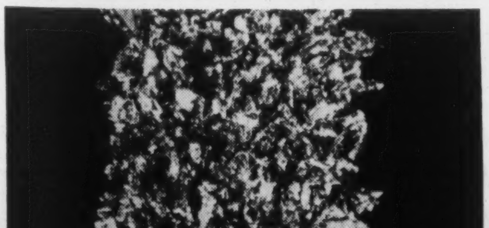
[a] Cond 50% R. H. at 73 F.
[b] Cond 48 hr at 122F, tested at room temp.
[c] Cond 48 hr, 50% R. H. at 73 F.

New Line of Polyesters Available Next Fall

A line of cellulose-filled, light colored polyester molding compounds will be made available next fall by Durez Plastics Div., Hooker Electrochemical Co., Niagara Falls, N. Y. The new polyesters, produced experimentally for about two years, will be made available in both regular and self-extinguishing grades.

The thermosetting molding compounds are readily molded and can be handled in conventional molding equipment. According to the producer, they have good shelf life and preforming characteristics. The new polyesters are similar to phenolic molding compounds in their physical properties, and are said to offer good color stability and heat and moisture resistance. Electrical properties of the polyesters are better than those of the phenolics. The new material, ranging in price from 42 to 77¢ per lb, will be sold in fine granular form.

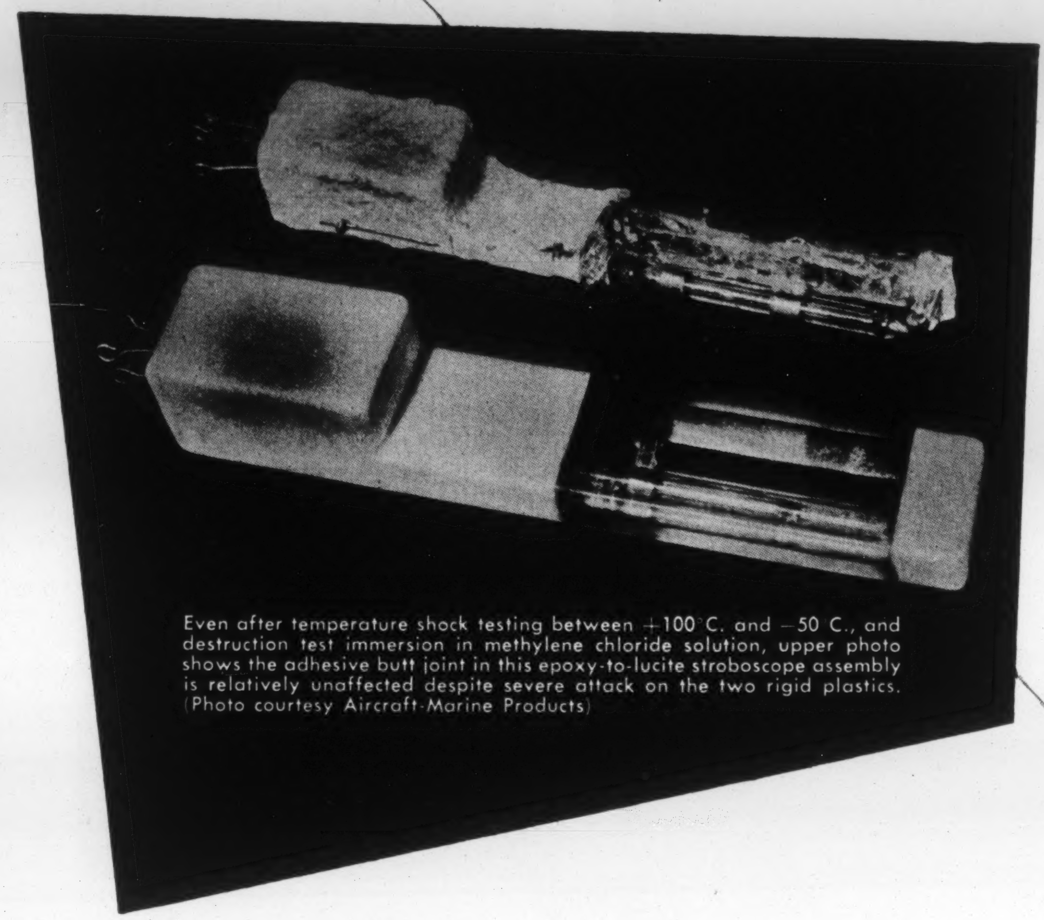
High Purity Metal Improves Chromium Alloys



As deposited *high purity iodide chromium (⅔ size).*

Chromium-base alloys containing a high purity iodide chromium metal have shown the greatest degree of ductility thus far demonstrated for chromium and chromium-base alloys. The iodide chromium, prepared by an improved iodide decomposition process developed at Battelle Memorial Institute, is available in limited quantities from Chilean Nitrate Sales Corp., 120 Broadway, New York 5, N. Y. The company believes a similar material can be commercially produced, and plans for its production are under consideration.

A number of unsuccessful attempts have been made in the past to increase the chromium content of high chromium alloys to obtain better high temperature properties. These attempts were unsuccessful because of the poor fabrication characteristics of the alloys (see photo p 177). However, recent investigations have shown that use of iodide chro-



Even after temperature shock testing between +100 C. and −50 C., and destruction test immersion in methylene chloride solution, upper photo shows the adhesive butt joint in this epoxy-to-lucite stroboscope assembly is relatively unaffected despite severe attack on the two rigid plastics. (Photo courtesy Aircraft-Marine Products)

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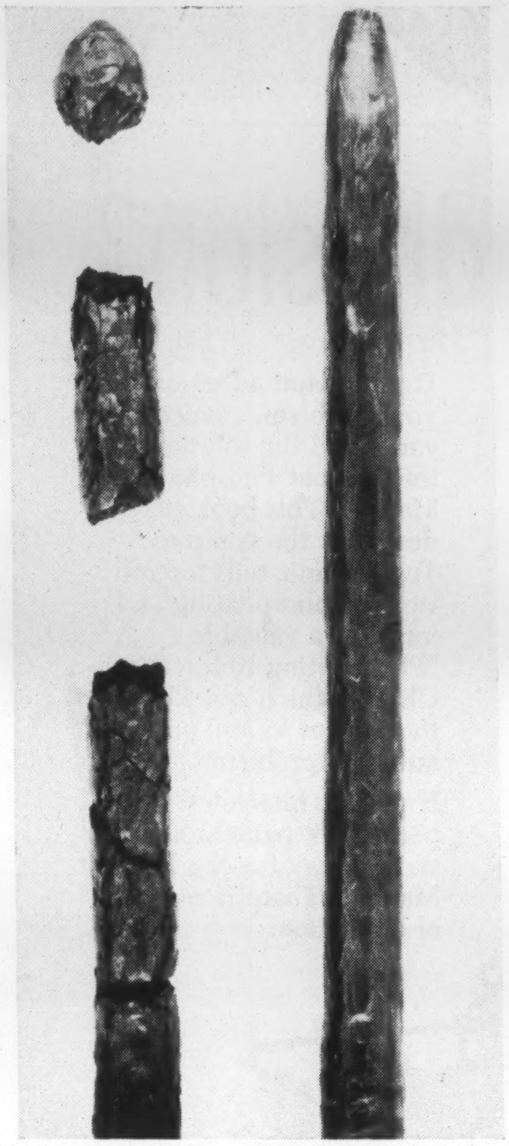
mium means that as much as 5 to 10% more chromium can be added to certain alloys without impairing either fabrication characteristics or room temperature ductility.

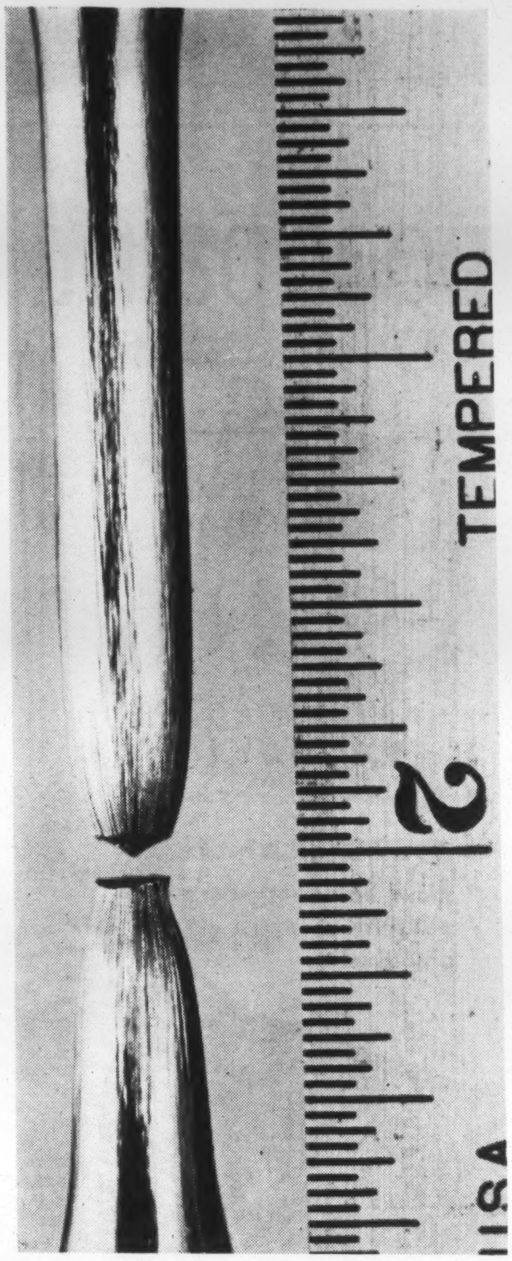
Improved ductility

In room temperature tensile tests, the new wrought chromium-base alloys have shown as much as 44% elongation and 78% reduction in area. The improved ductility is attributed to the iodide chromium and to the fibrous structure of the wrought metal. Modulus of elasticity was also improved to a certain extent in alloys containing iodide chromium. As yet, transverse ductility has not been determined.

Despite these favorable properties, the supplier says, considerable development will be required before iodide chromium alloys can be considered useful structural materials.



Fabrication characteristics *of iodide chromium (right) are compared with those of hydrogen treated electrolytic chromium (left). Both were sheathed in mild steel and swaged under identical conditions.*

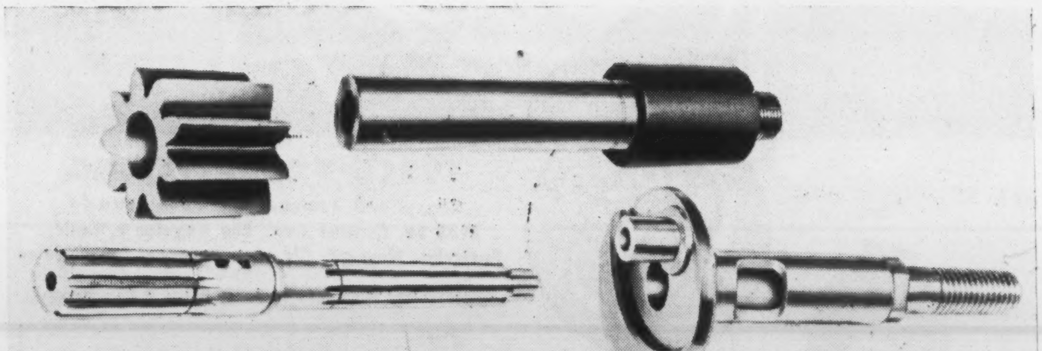


Fracture characteristics *of ductile iodide chromium metal.*

Here are further details on "e.t.d."

High Strength Steel Bars Need No Heat Treatment

■ Additional information has been made available on the Elevated Temperature Drawing ("e.t.d.") process La Salle Steel Co. uses to make steel bars having excellent physical and mechanical properties without heat treatment. Reported in the Dec '56 issue of MATERIALS & METHODS (p 143), the process is claimed to produce steel bar products in which, for the first time, the dimensional tolerances, surface finish and excellent machinability generally associated with cold finished bars



Improved bar stock *is used to make parts like these.*

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have been incorporated into a bar product which also has strength properties normally developed by heat treatment.

The properties depend upon three factors: 1) bar chemistry (0.40-0.48 carbon, 1.35-1.65 manganese, 0.04 phosphorus, 0.24-0.33 sulfur, and 0.15-0.30% silicon); 2) amount of reduction in cross section of the bar as it is drawn through a die; and 3) drawing temperature. As the bar is deformed at elevated temperatures (between 200 F and the lower critical temperature), three metallurgical phenomena take place: 1) the steel bar strain hardens by appropriate slip processes within the crystal structure; 2) it age hardens by precipitation of nitrides along with precipitation of carbon from supersaturated solid solution; and 3) a substructure develops within the grains.

The new material, called "Fatigue Proof," is claimed by the company to be the only material offered commercially with a guaranteed minimum Rockwell C value of 30, tensile strength of 140,000 psi and yield strength of 125,000 psi.

New Silicone Rubbers: Sponge, Low Shrink

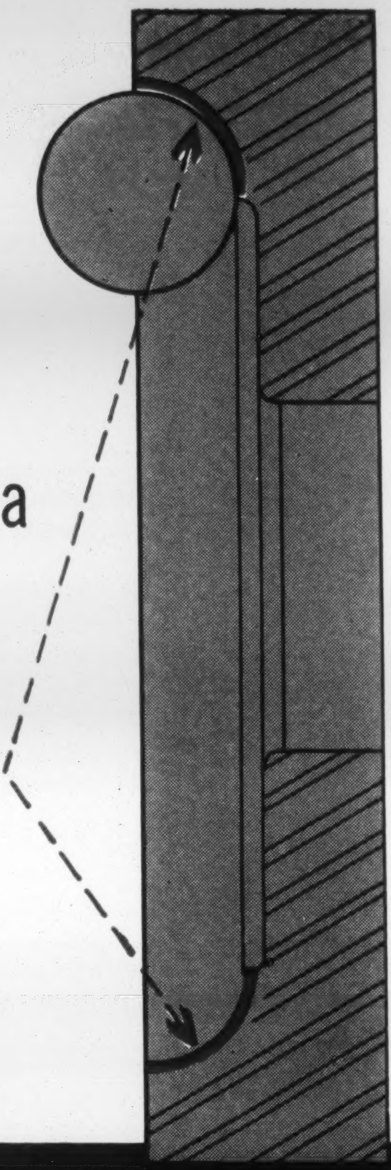
Four new silicone compounds have recently been introduced. One is a sponge rubber and the other three are low shrink compounds in the 50 through 70 durometer range.

1. Sponge rubber

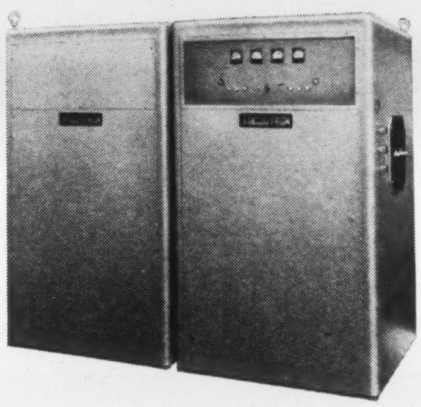
A new 50-durometer silicone sponge rubber has recently been marketed by Garlock Packing Co., Palmyra, N. Y. Designated Style 9383, the material is flexible at temperatures of −100 F and is resistant to temperatures up to 500 F. It resists tearing and abrasion and has good compression set.

The sponge rubber is available

If you have a
heat-treating
job like this



You need an
Induction Heating Machine
like this



New TOCCOtron Machine
50 kw 500,000 cycles

For many years TOCCO has led the Induction Heating Field—manufacturing both motor-generator and vacuum tube oscillator type machines to meet every induction heating requirement. This new 50 KW TOCCOtron unit is a big brother to the 25 KW unit which has been serving the Metal-Working Industry for many years.

Here's What It Does

With a frequency range of 350,000 to 600,000 c.p.s. the TOCCOtron unit is ideal for surface hardening small diameter parts to shallow depths (as the bearing race illustrated above), through hardening or annealing small sections and soldering or brazing small assemblies where the heating effect must be very strictly localized.

The greater capacity of the new 50 KW TOCCOtron *doubles* production rates formerly achieved by TOCCOtron equipment.

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Among the standard features of the 50 KW TOCCOtron are:

1. The industrial heavy gauge steel cabinet which completely encloses all high potential circuits preventing radiation interference and personnel hazards.
2. Meters in all sensitive circuits to enable the user to obtain the maximum output and efficiency.
3. 3-phase quadrature filament excitation of rectifiers for maximum life.
4. Externally adjustable grid bias and drive control for ease in setting up new production runs.
5. Externally mounted circuit breaker and disconnect located so that it is easily accessible.
6. Tapped plate transformer allowing variations of plate voltage.

If your operation requires the hardening, annealing or brazing of very small parts in very big quantities the new 50 KW TOCCOtron can do the job better, faster and at lower cost than any other method available.

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	L-WK-168	L-WK-170
ORIGINAL PROPERTIES		
Durometer A Hardness	57	77
Tensile Strength, psi	670	870
Elongation, %	135	80
Specific Gravity	1.23	1.41
AIR OVEN[a]		
Durometer A Change, %	0	0
Tensile Strength, Change, %	−1.8	−13
Elongation Change, %	−10	−18
ASTM No. 1 OIL[b]		
Durometer A Change, %	− 6	− 6
Tensile Strength, Change, %	+ 1	− 6
Elongation Change, %	0	− 8
Volume Change, %	+7.8	+ 7
Low Temp Flexibility[c]	OK	OK
Compression Set, %[d]	15	19

[a] Aged 70 hr at 450 F. [c] Aged 5 hr at −65 F.
[b] Aged 70 hr at 300 F. [d] Aged 24 hr at 350 F.

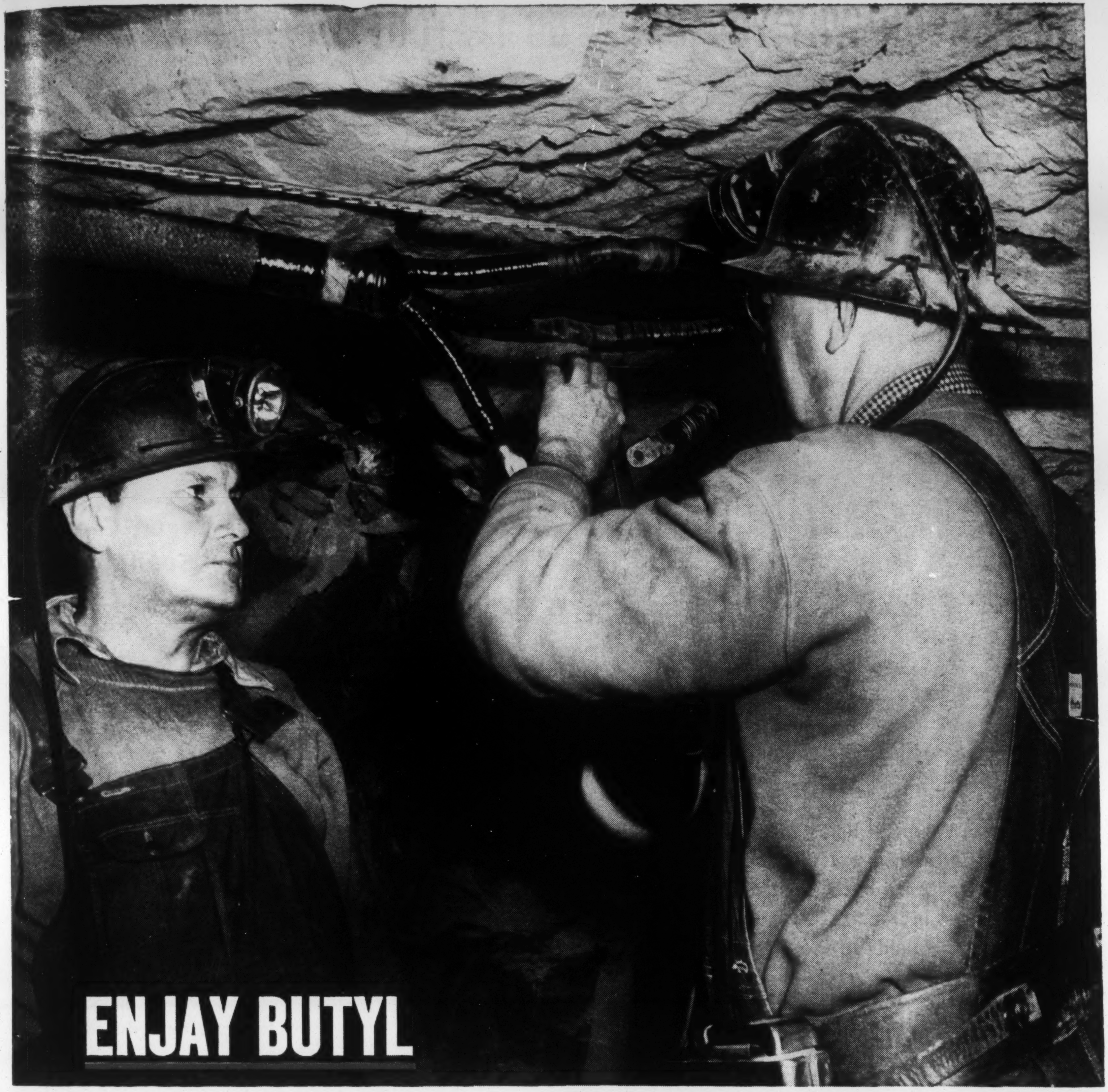
in sheets from 1/16 to ½ in. thick and in extrusions from ¼ to ¾ in. in dia. The material is recommended for aircraft door seals, ports and bomb bays.

2. Low shrink rubbers

Three low shrink silicone compounds in the 50 through 70 durometer range have been introduced by Acushnet Process Co., New Bedford, Mass. They are especially adaptable to o-rings and similar shapes, and their low shrinkage permits the use of tooling originally designed for organic rubbers. Free of toxic additives, the silicone rubbers can be used in the food and drug industries. Physical properties of two of the low shrink compounds are shown in the accompanying table.

Photosensitive Plastic? Needed for 3-D Models

A photosensitive thermoplastic resin to be used in the production of three-dimensional terrain models is now being sought by Horizons, Inc., of Cleveland. Working on a contract from the U.S. Naval Training Device Center, the research organization is trying to find such a material that will be



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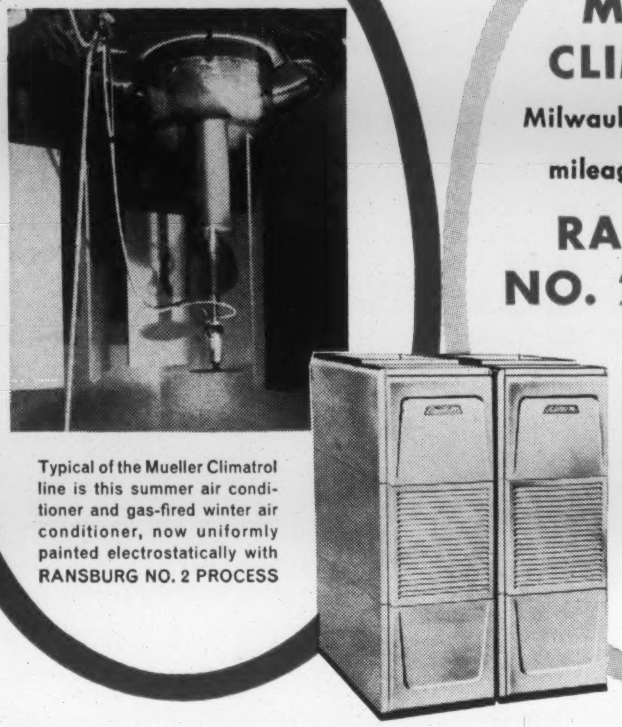

MUELLER CLIMATROL, Milwaukee, increases paint mileage 40% with RANSBURG NO. 2 PROCESS

And, 10 men averaging 40 hours a week now do the work formerly handled by 24 men averaging 50 hours!

Typical of the Mueller Climatrol line is this summer air conditioner and gas-fired winter air conditioner, now uniformly painted electrostatically with RANSBURG NO. 2 PROCESS

Painting used to be a bottleneck in the manufacture of heating and air conditioning equipment at Mueller Climatrol.

But not any more!

When Mueller modernized its finishing department—replacing hand spray with Ransburg No. 2 Process Electro-Spray—daily production was increased . . . finishing costs were cut . . . and quality of the work was improved.

Annually, Mueller coats over 10 million square feet of sheet metal, so a 40% increase in paint mileage—translated into paint dollars saved—is a sizeable figure. Pointing up other savings, a typical run of 400 furnace casings used to take 200 man hours to clean and hand spray. Mueller does it now in 60 hours!

NO REASON WHY YOU CAN'T DO IT, TOO!

Whatever your product, if your production justifies conveyorized painting, chances are one of the Ransburg Electro-Coating Processes can do it better, for less, with improved uniformity and quality of the work. Write for our new brochure which includes numerous examples of both large and small manufacturers of a variety of products who are enjoying the many advantages of *Ransburg Electrostatic Spray Painting.*

Ransburg ELECTRO-COATING CORP.
Indianapolis 7, Indiana
RANSBURG

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thermally stable at temperatures of 300 F.

Contour lines and names of rivers, towns, hills and mountains, and other important terrain features will be transplanted from a negative to the resin through a photographic process. The resin will then be molded to a three-dimensional shape.

Copper-Cored Glass Wire for Sealing

By inserting a solid OFHC (oxygen-free high conductivity) copper core in a seamless sleeve of glass sealing alloy, General Plate Div. of Metals and Controls Corp. has come up with a sealing alloy wire that is claimed to have three times the electrical conductivity of solid alloy wire.

The new material is claimed to increase current carrying capacity with no increase in diameter, i.e., the same diameter wire can be used to meet demands for increased conductivity. If greater current capacity is not required, wire size can be reduced proportionately.

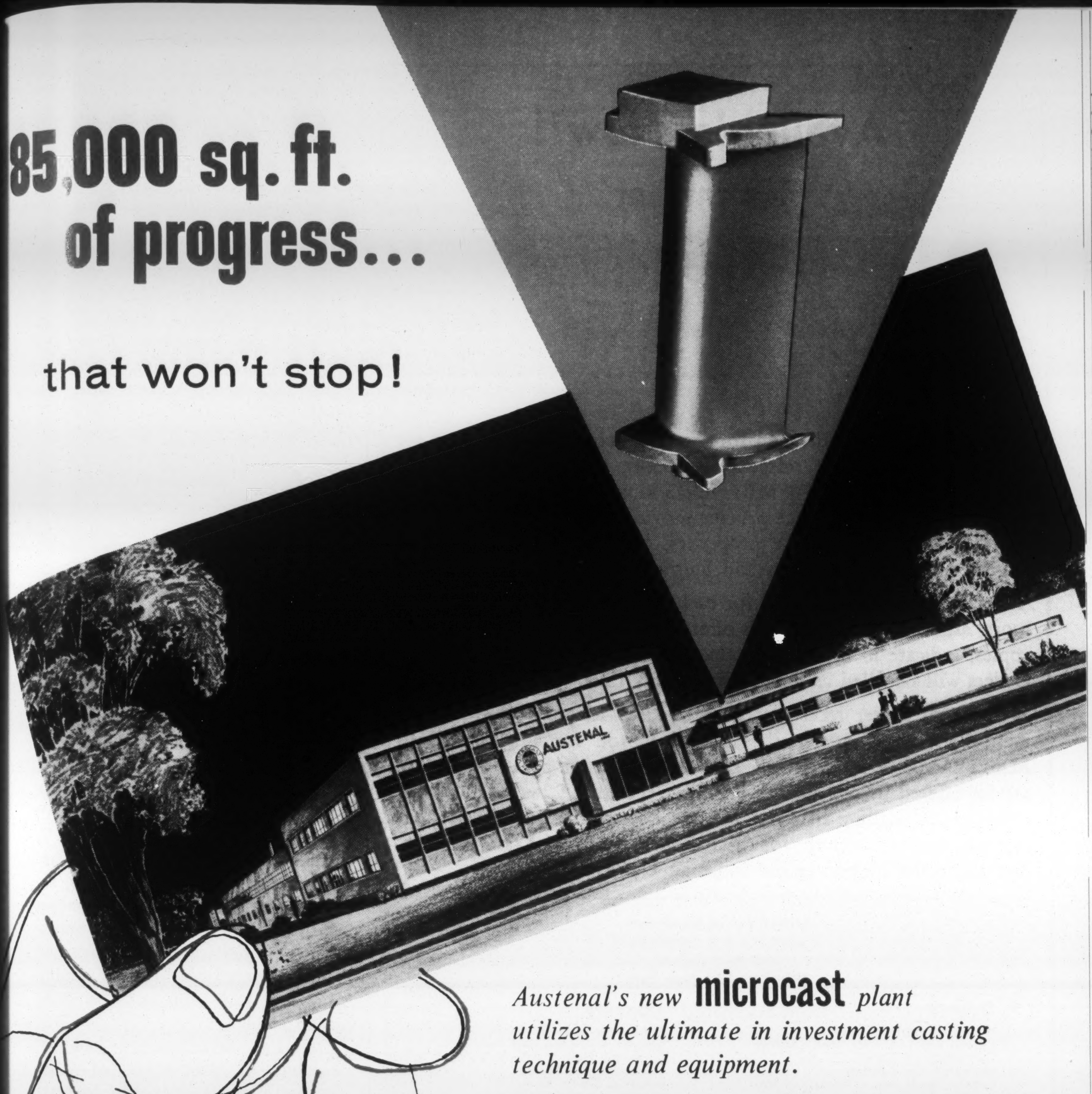
Among the applications listed for the material are glass-to-metal seals for terminals and terminal blocks, and hermetic seal headers for unit terminals, switches, relays, coils, capacitors, rectifiers, transformers and potentiometers. The wire, supplied in coils, is available in diameters from 0.010 to 0.250 in. and in annealed or cold drawn tempers.

Cadmium Plating Bath Produces Bright Parts

A new cadmium plating process called Cadalume is said to increase brightness of the electroplate up to 10%. The life of plating bath brighteners is increased 400% and plating speeds

85,000 sq. ft. of progress...

that won't stop!



Austenal's new **microcast** *plant utilizes the ultimate in investment casting technique and equipment.*

Pioneer and leader in investment casting, Austenal, Inc., is building a new 85,000 square foot plant to augment its present Microcast production facilities.

Austenal's new LaPorte, Indiana plant will allow for greater casting versatility, with the precision and superiority inherent in Microcast parts.

New production line vacuum furnaces, designed especially for Austenal, will make possible the melting of high temperature alloys never before castable.

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are increased up to 10% with the new method. Developed by Hanson - Van - Winkle - Munning Co., Church St., Matawan, N. J., the process uses two brighteners: one for making up a new bath, the other for maintenance additions.

The clearness of the new plating bath helps in arranging work in either unlined or lined steel tanks.

Effect of Silicon on Properties of 4340

Transverse ductility is a major design criterion in the selection of steel for use in aircraft where tensile strengths in the range 200,000-300,000 psi are required. Since high-silicon alloys are among those used in aircraft the effects of silicon on transverse properties are of some interest. Accordingly, John Vajda, John T. Hauser and Cyril Wells, of Carnegie Institute of Technology, recently conducted an investigation to determine the effects on transverse properties in the quenched and tempered condition of adding 1% and 1.5% silicon to an AISI 4340 steel.

Earlier investigators had demechanical properties of high strength steels quenched to martensite and subsequently tempered to various tensile strengh levels. This new investigation was designed to determine the properties of high strength steels of such mass and so end quenched that a whole range of structures would be developed during quenching.

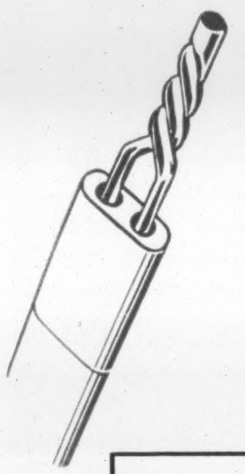
Some of the conclusions reached by the investigators and presented at the 38th annual convention of the American Society for Metals, are:

1. The maximum tempering temperature at which silicon increased resistance to softening during tempering seemed to be higher in fully quenched than in slack quenched steels.

2. The ratio of yield strength

Driver-Harris Announces Major Advance in Pyrometry!

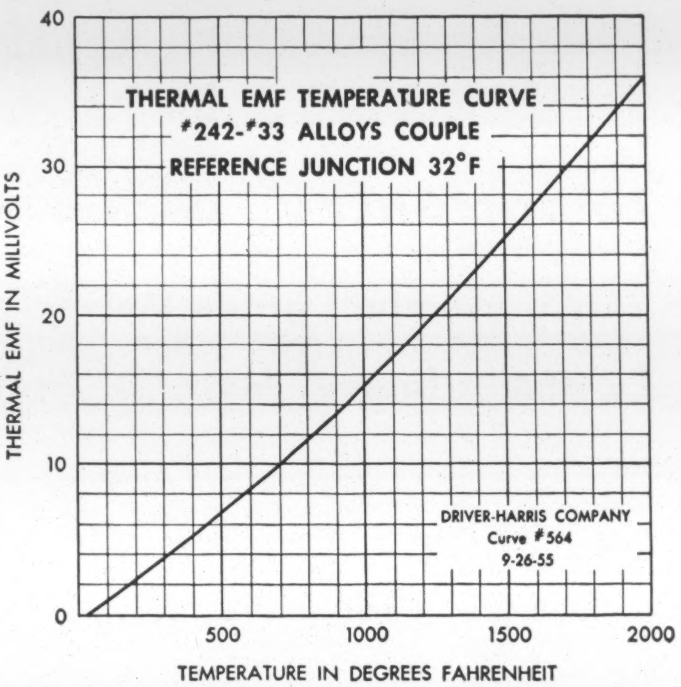
New #242-33 Thermocouple* for Reducing Atmospheres Maintains Calibration Through a Greatly Extended Life



This new Driver-Harris Thermocouple was developed primarily to withstand industrial reducing atmospheres at high temperatures and thereby to end the danger of runaway furnaces and ruined charges.

Unusually high resistance to "green-rot" attack is the outstanding property of the alloys of this thermocouple, whose analysis is:

Positive Leg (No. 242 Alloy)	**Negative Leg (No. 33 Alloy)**
80/20 Ni-Cr + Cb	3% Si-Ni



Although the thermal-emf response of this thermocouple is lower than the conventional thermocouple now in use, the slope of its temperature-emf curve is virtually parallel in the higher ranges of temperature in which both couples are designed to be used. Thus, the thermal-emf sensitivities are equivalent in the higher temperature ranges.

Tested against the conventional thermocouple in an atmosphere of the following nominal composition: CO...10%; CO_2...5%; CH_4...1%; H_2...16%; O_2...Nil; N_2...Balance (best for accelerating green-rot attack), exposure after 212 hours showed *only +0.13 mv. drift for the D-H thermocouple, and −7.54 mv. for the conventional thermocouple.*

When the thermal-emf of the conventional thermocouple *drops,* as in a reducing atmosphere such as this, the working temperature of the furnace controlled by it *rises.* However, when a #242-33 couple is used under the same conditions the thermal-emf remains substantially constant. This means that a furnace controlled with the new D-H thermocouple *cannot overheat and ruin charges.*

Members of the Heat-Treating and Instrument Manufacturing Industries are urged to investigate this new Driver-Harris Thermocouple without delay so that through their combined efforts all U. S. Industry can benefit. Complete technical data and application information is waiting for your inquiry. Write today to our Thermocouple Division.

*U. S. Patent No. 2,691,690

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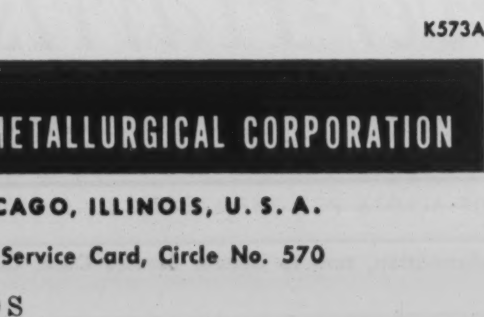

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to tensile strength in end quenched 7- by 7-in. rounds was decreased by silicon additions.

3. Marked improvement of both the yield strength and the yield to tensile ratio occurs as a result of tempering 17 hr at 500 F. It appears to be essentially independent of the transformation of retained austenite and may be associated with the relief of stress during tempering.

4. For a tempering treatment of 17 hr at 500 F, the addition of 1.5% silicon to AISI 4340 steel improves transverse reduction of area and transverse V-notch Charpy impact quality in 7-in. rounds. This treatment also improves transverse ductility and transverse toughness of the slack quenched, but not the fully quenched, material to which 1% silicon has been added. At a tempering temperature of 800 F both properties are impaired by added silicon.

5. Since the effect of silicon on transverse mechanical properties was determined over a very large range of cooling rates, the findings are applicable to large, massive forgings as well as to small forgings.

Intricate Coring for Aluminum Castings

A sheathed tube method of coring aluminum and magnesium castings has been developed by Howard Foundry Co., 1701 N. Kostner Ave., Chicago 39, Ill. The core consists of a preformed metal tube sheathed in a flexible refractory sleeve. Both the tube and the sleeve are removed after molding the casting.

The coring process permits small intricately shaped, unlined passages in sand castings. It is used when it is impossible to mold a passage with a sand core or when sand coring costs are high. Passages for transmitting oils, fuels, coolants and hydraulic

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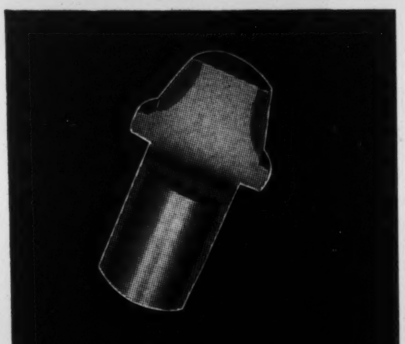
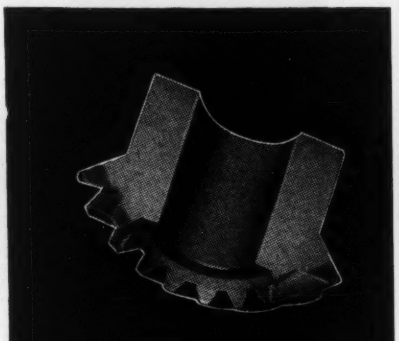
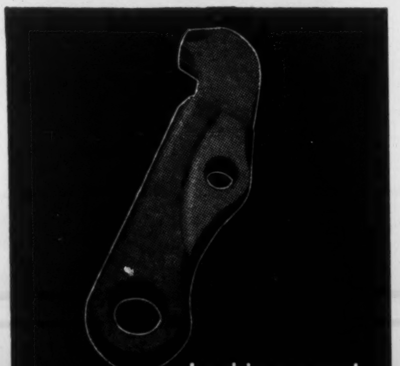


Locking pin



Bevel gear

Steering arm ball stud



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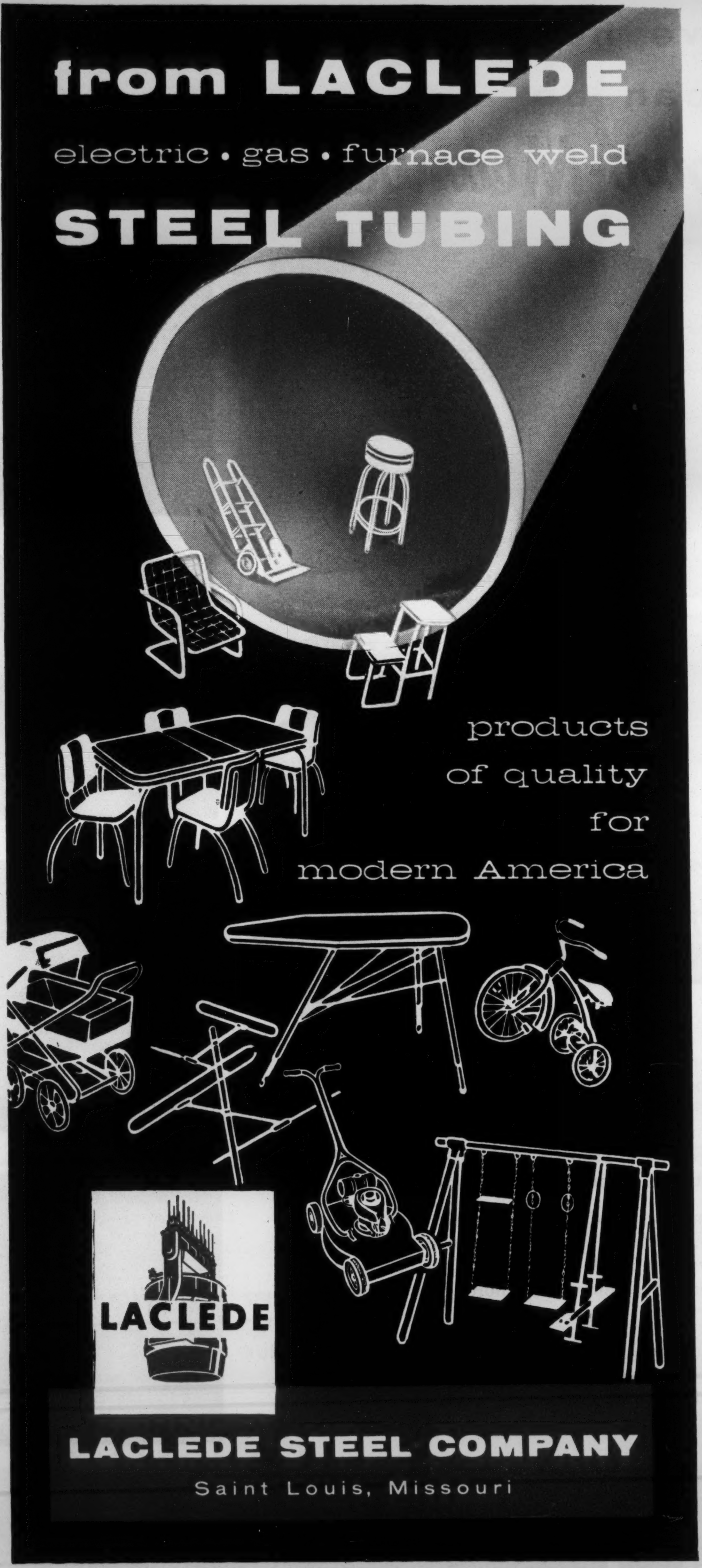
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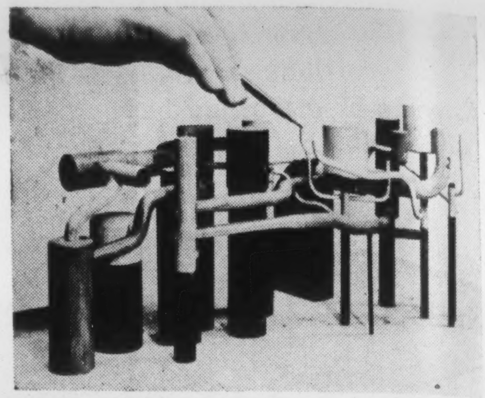

Passages *for aluminum aircraft fuel control units are shown in this core mock-up.*

fluids do not have to be attached to exteriors of cast components nor do holes have to be drilled.

According to Howard Foundry, rigidity and dimensional stability of the sheathed tube core makes possible the casting of ⅛ in dia passages. The process is also adaptable to large core diameters.

Plastics Tubes, Shapes Made in Large Sizes

Large extruded plastics tubes and shapes—up to 3 in. i.d.—are now available from Anchor Plastics Co., Inc., 36-36 Thirty-Sixth St., Long Island City 6, N. Y. The hollow shapes may be obtained with heavy or thin wall thicknesses; in oval, rectangular and flanged cross sections; and with special surface effects such as ribs, beads and flutes.

Finishing Process Adds Sparkle to Aluminum

A new metal finishing technique which produces a startling glitter on the surface of aluminum sheet was recently announced by Aluminum Co. of America. Called "Spangle Sheet," the unusual effect is achieved by inducing the formation of abnormally large grains in a special aluminum alloy. Individual grains are then made to stand out in relief

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Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

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PRACTICAL ANSWER TO STATIC DUST COLLECTION

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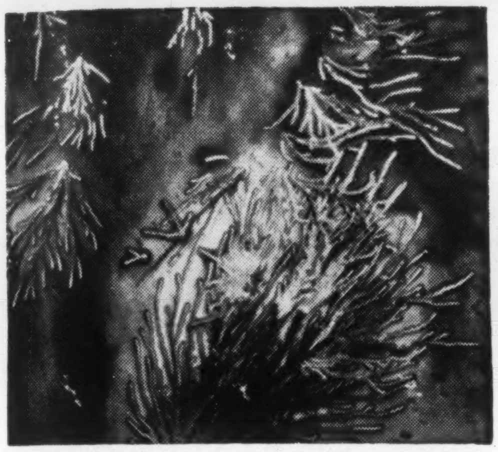

FIGURE 1

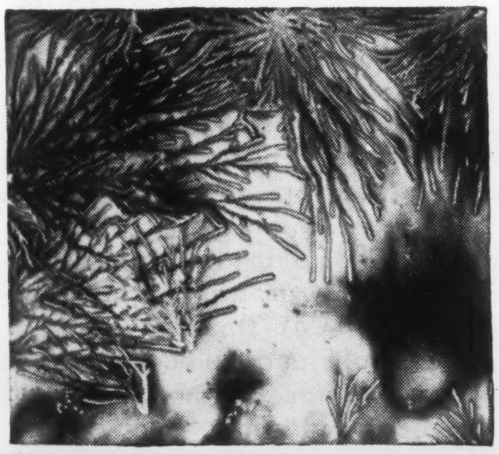

FIGURE 2

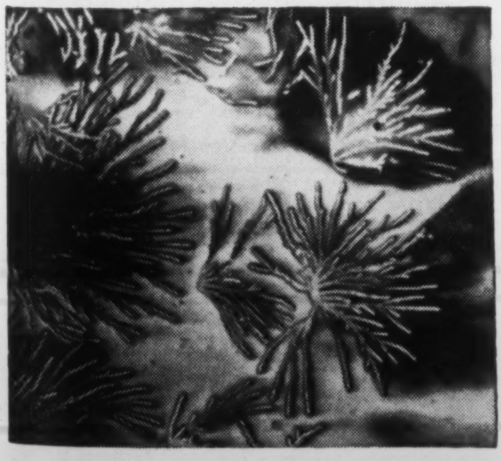

FIGURE 3—*Figures 1, 2 and 3 show typical static dust patterns on nontreated plastic surfaces as reproduced by Dow process using fluorescent pigments and "black light".*

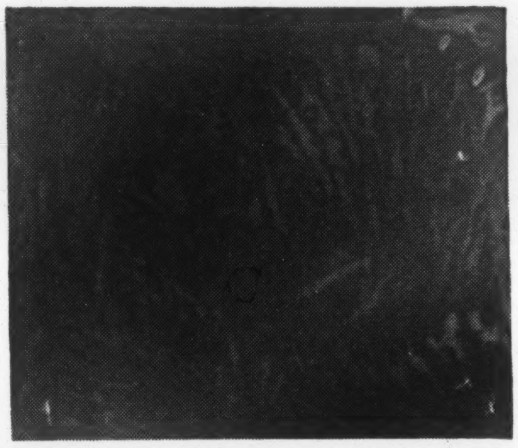

FIGURE 4—*Here the same "black light" technique shows the absence of static charge on plastic surfaces destaticized by new method.*

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- STYRON 480 (Extra High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700

Static electricity which attracts and holds dust has long been acknowledged a problem in the manufacture and use of plastic products.

To overcome this behavior, Dow Plastics Technical Service developed new techniques for obtaining, observing and recording dust deposits. With these tools, Dow research explored hygroscopic chemicals that render the surface hydrophyllic or, in other words, that destaticize it.

A method was developed and conclusively tested to provide freedom from static for long periods of time. This method includes dipping, spraying or otherwise coating moldings with a dilute detergent solution that reduces electrostatic charges to levels that prevent dust pickup.

FREE BULLETIN

A list of suitable compounds together with further information on this subject are contained in the bulletin, "Static Dust Collection of Plastics". Address: THE DOW CHEMICAL COMPANY, Midland, Michigan—Plastics Sales Department PL1540H.

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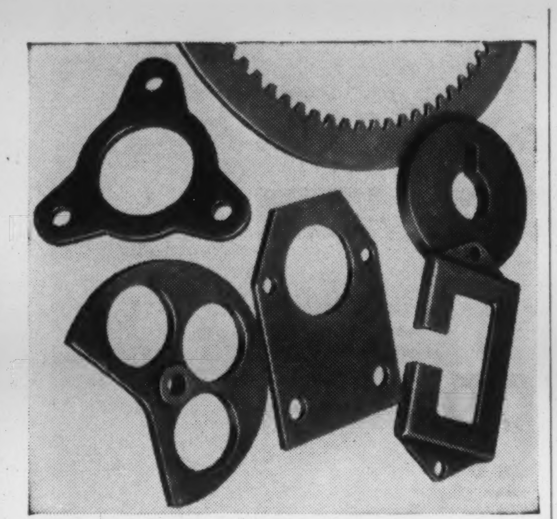

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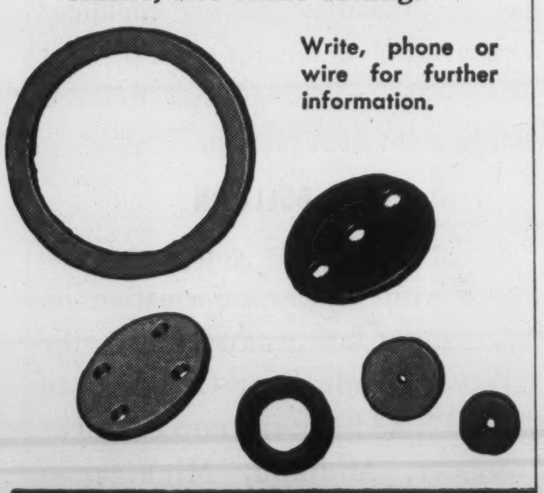

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Vulcan 3-7900

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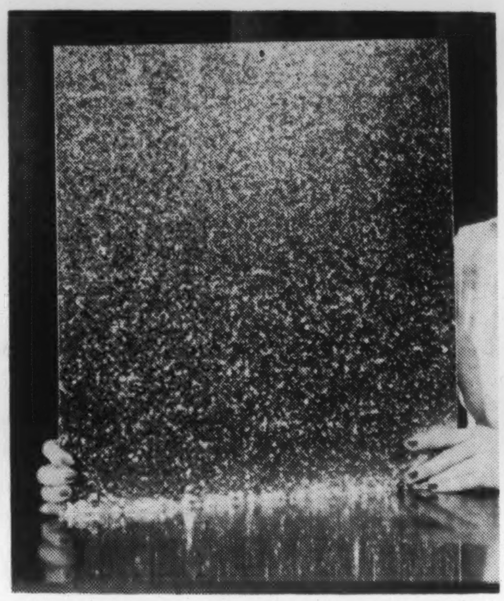
What's new IN MATERIALS



Mirrorlike facets *catch light and cause sparkling on aluminum surface.*

by an acid etch, which also forms tiny mirrorlike facets on each grain. As the light source, the aluminum sheet or the position of the observer is moved, waves of light sparkle across the surface.

The new material, though not now commercially available, will be supplied by Alcoa in its finished form.

Comparison of Leaded and Nonleaded Steels

The effects of lead on the physical properties and the Charpy impact characteristics of leaded steels have been the topic of much discussion and investigation. Not a great deal has been done, however, on the differences, if any, between the Charpy impact characteristics of leaded and nonleaded steels. A. P. Weaver, of Inland Steel Co., reported on such an investigation at the 38th annual convention of the American Society for Metals. Working with C-1050 and C-1141 steels, Mr. Weaver found that:

1. Charpy impact transition temperatures, in seven out of eight instances, averaged 22 F lower for leaded steels than for the corresponding nonleaded grades.
2. There were no significant

below 800° F.

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Low temperature
Xactemp Pyrometer
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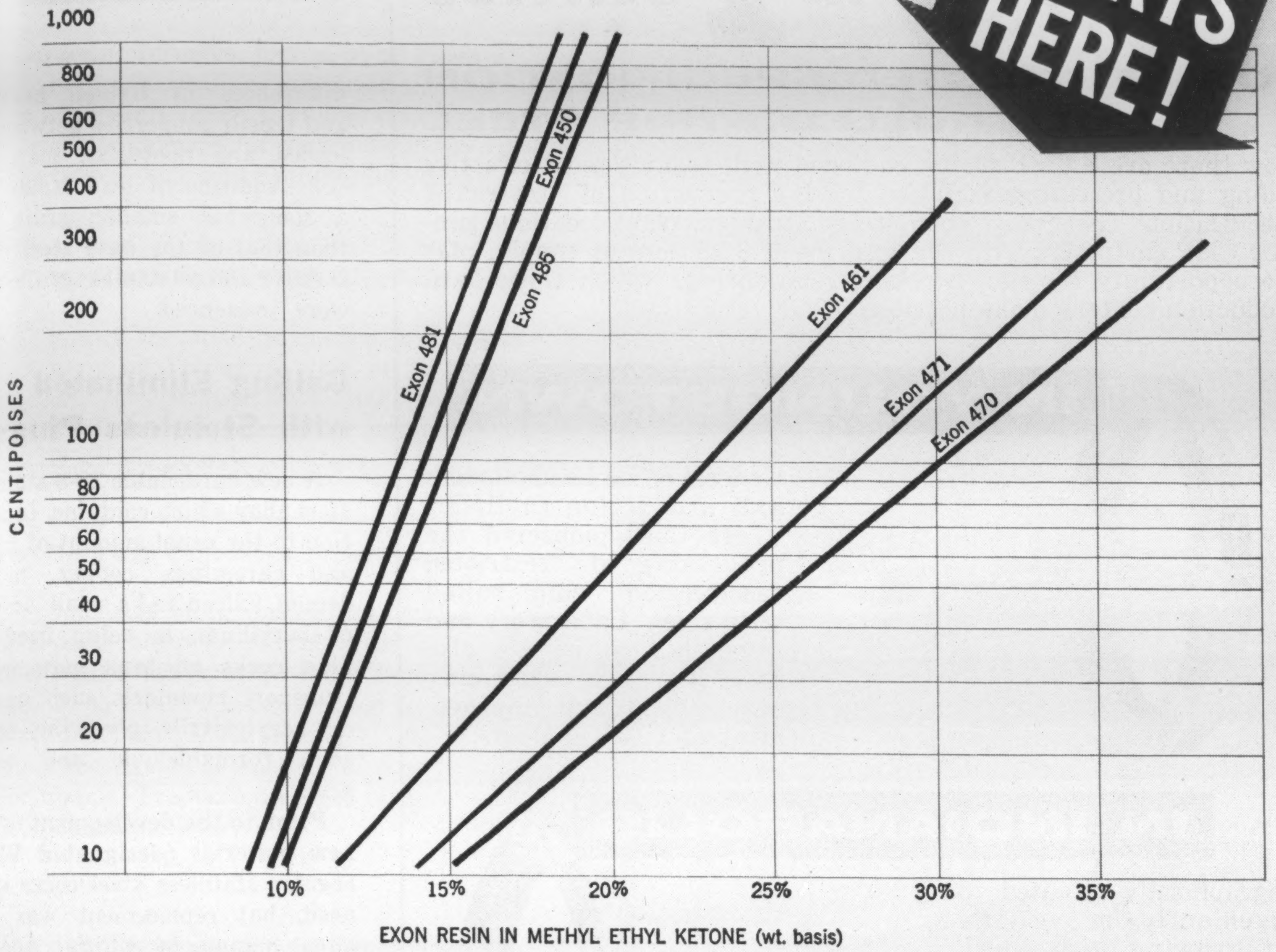
SUCCESS IN COATINGS STARTS HERE!



EXON CHARTS SOLUBILITIES to help you choose the resin with properties Pin-Pointed to your special needs!

EXON 450 Ideal for strip coatings. Good solubility, tensile strength and durability.

EXON 461 A unique fluorine-containing resin combining high solubility, unusual chemical resistance, heat stability and weatherability.

EXON 470 Excellent adhesion to metals, alkyd and vinyl surfaces. Compatible with wide range of drying oils, alkyds, phenolics, melamines. High solubility in inexpensive solvents.

EXON 471 Excellent for weatherability and durability in a protective coating. Corrosion resistant. No measurable change after sunlamp exposure for 360 hours as 1 mil film.

EXON 481 Makes possible colorful, abrasion-proof, washable coatings that resist fading or cracking.

EXON 485 For superior strip coatings. Lower viscosity makes application easier and shelf-life better. Good clarity.

Firestone
EXON.
RESINS

THE special nature of Exon resins—"Pin-Pointed Properties" to supply specific answers to special needs—is particularly desirable in the manufacture of coatings.

Because products and processes vary, Firestone Exon has engineered 6 solution resins to help you formulate a successful coating. Each resin differs in properties, such as the solubility factor charted above, to suit various applications.

One property in common: superior quality of performance with the resultant production speed and savings which have made Firestone Exon industry's No. 1 source of specifically engineered vinyl resins.

We suggest you keep this chart handy—to help you put your finger on the right resin for *you*—at a glance.

For complete information and technical service, call or write:

CHEMICAL SALES DIVISION
FIRESTONE PLASTICS COMPANY, DEPT. 73F,
POTTSTOWN, PA.
A DIVISION OF THE FIRESTONE TIRE & RUBBER CO.

CHEMICAL PROGRESS WEEK-APRIL 8-12

INDUSTRY'S MOST COMPLETE LINE OF VINYLS ENGINEERED TO YOUR SPECIFIC NEEDS

For more information, turn to Reader Service Card, Circle No. 376

TRY
CMP's 3 IN 1 SERVICE
FOR RESTRICTED SPECIFICATION
COLD ROLLED STRIP STEEL

Now there are 3 CMP plants equipped with today's most effective rolling and processing facilities for the production of "restricted specification" cold rolled strip steel. Strategic plant locations provide CMP customers with the security of 3 sources of supply, plus the opportunity for close working relationships which these local production centers make possible.

IN YOUNGSTOWN

General office headquarters and production facilities where CMP pioneered the processing of "restricted specification" cold rolled strip steel. Laboratory and research facilities are also here, staffed for continuing development and improvement of CMP products.

IN INDIANAPOLIS

Geographically situated to conveniently serve the fast growing midwestern market for specialized cold rolled strip, this recently built, all-new plant utilizes identical processing equipment as other CMP plants for producing a wide range of "restricted specification" cold rolled strip.

IN LOS ANGELES

Latest addition to CMP's producing facilities is this Los Angeles unit, the only plant in the West with CMP-type equipment. Faster service for West Coast steel fabricators, plus the know-how of steel mill-trained personnel provide a service opportunity not heretofore locally available.

TRY CMP FOR 3 IN 1 SERVICE
Low Carbon, High Carbon — Annealed or Tempered, Stainless, Alloy, Electro Zinc Coated.

THE COLD METAL PRODUCTS CO.
GENERAL OFFICES: YOUNGSTOWN 1, OHIO
PLANTS: YOUNGSTOWN, INDIANAPOLIS AND LOS ANGELES
SALES OFFICES: NEW YORK - CLEVELAND - DETROIT - INDIANAPOLIS
CHICAGO - LOS ANGELES - SAN FRANCISCO

For more information, turn to Reader Service Card, Circle No. 543

differences in Brinell hardness and tensile properties between the leaded and nonleaded materials.

3. Addition of lead resulted in a somewhat smaller grain size than that of the base steel; both ferritic and austenitic grain sizes were influenced.

Galling Eliminated with Stainless Plugs

A new hardenable 18-8 stainless steel alloy which contains, in addition to the usual amount of nickel and chromium, copper, molybdenum, silicon and a small amount of beryllium, is being used for plug cocks on tank cars which transport chemicals such as tall oil, acrylonitrile, glycerine, acetic acid, formaldehyde and nitric acid.

Prior to the development of the new material (designated V2B), regular stainless steel cocks were used, but replacement was frequent because of galling. According to Cooper Alloy Corp., manufacturer of the plug cocks, this problem has been completely eliminated.

The new hardenable alloy is soft enough to be readily machined in the quench-annealed condition. It is normally water quenched from 2000 F, which puts the beryllium in solution and also

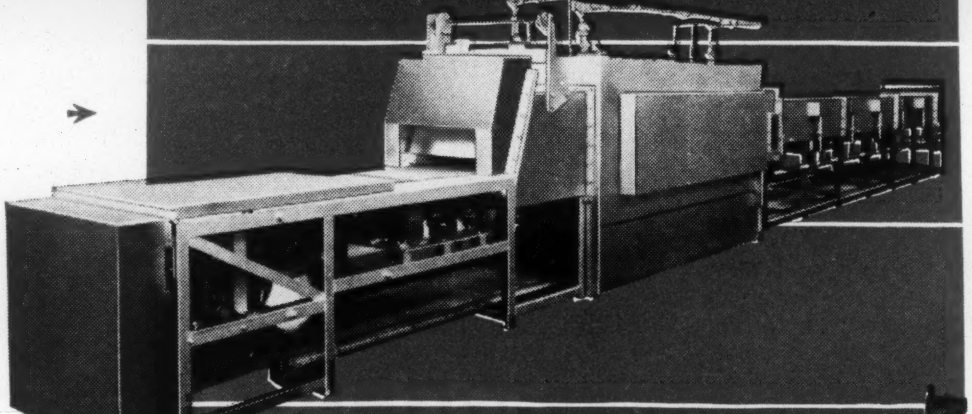
***New stainless alloy** plug cocks, installed on General American Transportation Corp. tank cars, are corrosion resistant and nongalling.*

Look to Lindberg for Sintering Furnaces

For sintering furnaces, just as in all types of industrial heating equipment, you can depend on Lindberg's ability to supply exactly the right equipment for your needs. Here are some typical Lindberg sintering furnaces:

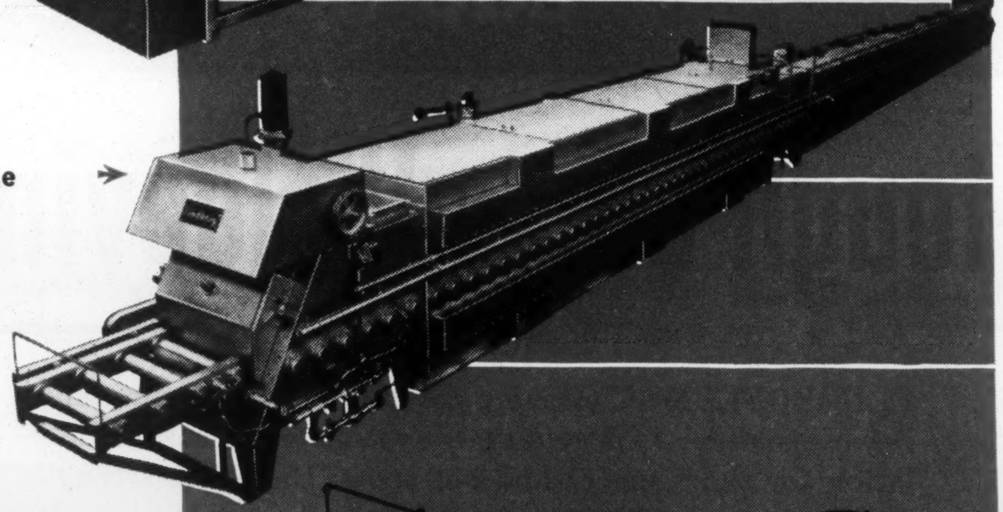
This Hand Pusher Batch Type Furnace →

is used for small production lots and experimental sintering. It is an all-purpose unit for operation from 1300°F to 2500°F. Made in various sizes for sintering from 25 to 300 pounds per hour.



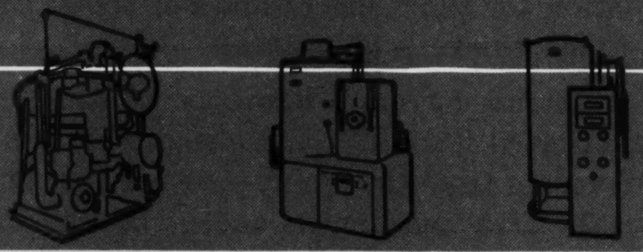
This Mesh Belt Continuous Type Furnace →

is a popular sintering furnace for small light parts in copper, bronze, brass or steel with a temperature range from 1300°F. to 2100°F. It can be used for low temperature silver brazing, bright annealing, as well as sintering of powder metals. Production ranges up to 500 pounds per hour.



This Roller Hearth Continuous Type Furnace →

is especially designed to handle heavier loads up to 2200 pounds per hour. It has an effective temperature range from 1300°F. to 2100°F. It can be used for bright annealing, low temperature silver brazing as well as sintering of powder metals.



Atmosphere Generators →

To obtain the best work from any sintering furnaces, the proper atmosphere is required. The atmosphere generators described here provide the proper atmospheres recommended for use with Lindberg Sintering Furnaces.

1. The HYEX Generator produces atmosphere composed of approximately 4% carbon dioxide—18% hydrogen—12% carbon monoxide and 66% nitrogen.
2. The HYEN Generator produces a neutral atmosphere composed of approximately 21% carbon monoxide—40% hydrogen—38% nitrogen and 1% methane.
3. The HYAM Generator produces atmosphere composed of approximately 75% hydrogen and 25% nitrogen.

If you have a sintering or brazing problem why not talk it over with Lindberg. Just get in touch with your nearest Lindberg Field Representative or write us direct.

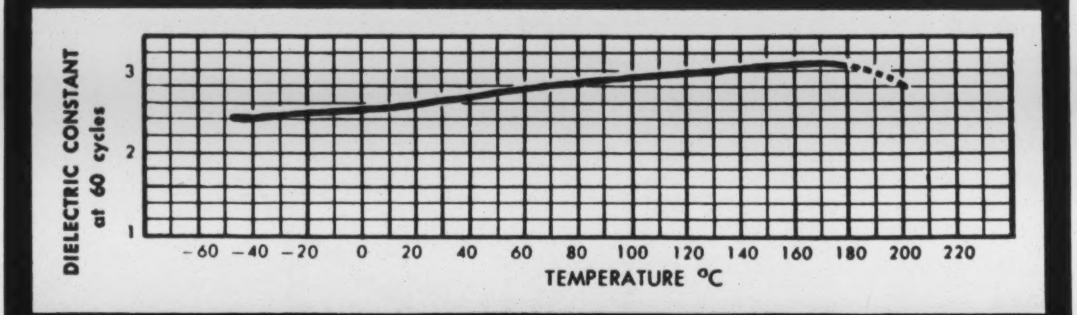
LINDBERG ENGINEERING COMPANY

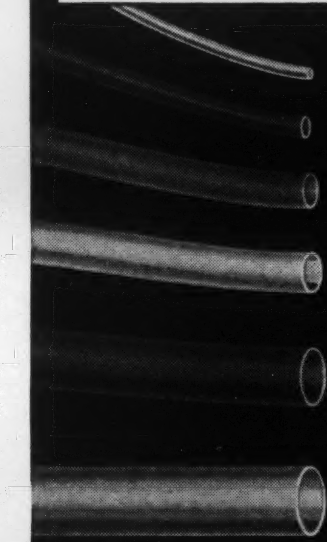
2451 W. HUBBARD ST., CHICAGO 12, ILL.

Los Angeles Plant: 11937 S. Regentview Ave., at Downey, Cal.

For more information, turn to Reader Service Card, Circle No. 581

This heat range





+ abrasion resistance
+ corona resistance
+ mechanical strength
+ moisture-proofness
+ flame-proofness
+ fungus-proofness

add up to . . .

tough Class H sleeving

FLUOROFLEX®-C sleeving combines *all* these outstanding properties . . . providing the ultimate in Class H insulation for tight spaces and hot spots. Dielectric strength (.060″ thick) is 500 v./mil.

Extruded from a new type of Kel-F® resin which has improved flexibility and elongation, this sleeving assures freedom from the pinholes or porosity encountered (especially after mechanical abuse) in other more costly sleevings for 180°C service (356°F).

FLUOROFLEX-C sleeving is available transparent and in translucent standard colors—for wire harnesses, leads, terminals and resistors. Sizes start from "spaghetti" for No. 24 wire and go to 1¼″ I.D. Send for data.

® FLUOROFLEX is a Resistoflex trademark. Kel-F is an M. W. Kellogg trademark.

20th year of service to industry

RESISTOFLEX

CORPORATION • Roseland, N. J. • Western Plant: Burbank, Calif.
Southwestern Plant: Dallas, Tex.

For more information, turn to Reader Service Card, Circle No. 404

keeps in solution carbides which are detrimental to corrosion resistance. After quenching, the metal is machined, hardened by holding at 925 F for 8 hr, and subsequently furnace cooled. No distortion or harmful carbide precipitation is produced in the relatively low temperature hardening operation.

Epoxy Potting Resin for Electrical Parts

A new epoxy resin designed especially as a potting and encapsulating compound for electrical parts is being marketed by Furane Plastics, Inc., 4516 Brazil St., Los Angeles 39.

When cured, Epocast 15-E has a nominal Shore D hardness of about 46, but it is possible to adjust the hardness by varying the proportions of the material with a hardener. Materials ranging from semisolids to soft rubber-like solids are possible from this combination of resin and hardener.

The new epoxy requires elevated temperatures to effect cure—generally 6-10 hr at 200 F, followed by 2 to 3 hr at 250 F.

The material may be used as a sealant for porous metal castings, as an impregnant for woven mats and gasketing fabrics, and as an integral casting for use as a shock absorber.

(more What's New on p 197)

TYPICAL PROPERTIES OF EPOCAST 15-E

Tensile Strength, psi	12,000
Elongation, %	70
Shore D Hardness	50
Density, gm/cu cm	1.16
Water Absorption (24 hr), %	0.2
Dissipation (power) Factor	
110 kc	0.039
1.0 mc	0.042
11.0 mc	0.053
Dielectric Constant	
110 kc	3.20
1.0 mc	3.10
11.0 mc	3.00

New Chemical Process for Descaling Titanium

Development of a process that efficiently descales titanium and its alloys without adversely affecting physical and chemical properties has been announced by Turco Products, Inc., Los Angeles.

Claimed to eliminate the disadvantages of descaling titanium by sand blasting, vapor blasting or immersion in molten salt baths, the new process requires only relatively low temperatures (270-280 F, as compared with 800-900 F in salt baths). Two immersion steps (one for scale conditioning and one for scale removing) and two rinsing steps are required.

The process is said to give 100% chemical cleanliness without warping thin gage material. It does not cause salt entrapment on the metal's edges nor does it create fire hazards. The descaling bath is suitably inhibited to prevent hydrogen pickup and resultant embrittlement, and it keeps metal loss low (0.0001-0.0003 in. per side).

Hard Vinyl Coating for Metal Surfaces

An organosol formulation specifically designed as a metal coating has been developed by the Goodyear Tire & Rubber Co., Chemical Div., Plastics Dept., Akron 16, Ohio. Based on a vinyl dispersion resin, the coating is formulated with 35 parts of plasticizer per 100 parts of resin. The coating's low plasticizer content permits a harder coating with less tack and greater chemical resistance than is possible with comparable formulations having higher plasticization.

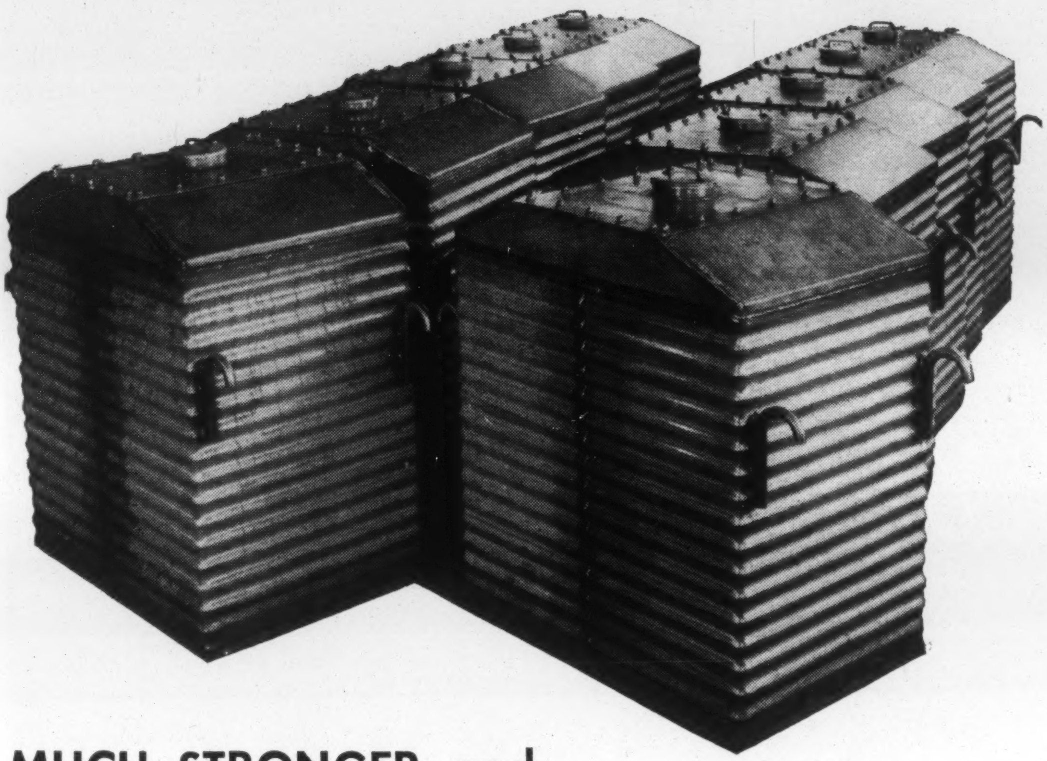
An adhesive plastisol primer is recommended for use with the coating to assure maximum adhesion to metal surfaces. Dilution with a mixture of mineral spirits

◂ For more information, Circle No. 619

ROLOCK

FABRICATED ALLOYS

HEAT AND CORROSION RESISTANT



MUCH STRONGER and MUCH LIGHTER process vessels with ROLOCK'S new

CORRUGATED

WELDED CONSTRUCTION

All the advantages of lighter weight, rapid heat transfer, easier handling and lower over-all cost are inherent in this Rolock-perfected construction technique. Yet there is no sacrifice of strength or anticipated performance. In fact, vessels such as those shown above, of Type 316 Stainless Steel, can be expected to out-perform alternative designs in every way.

Skilled Rolock craftsmen, using specially developed equipment and technique, form the corrugated construction WITHOUT welding at the corners — a very important feature.

This is another example of the way in which Rolock designing and welded fabrication skills can help you meet new or unusual equipment needs. Always consult us first.

SALES AND SERVICE REPRESENTATIVES FROM COAST TO COAST

ROLOCK INC., 1282 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

5RL57

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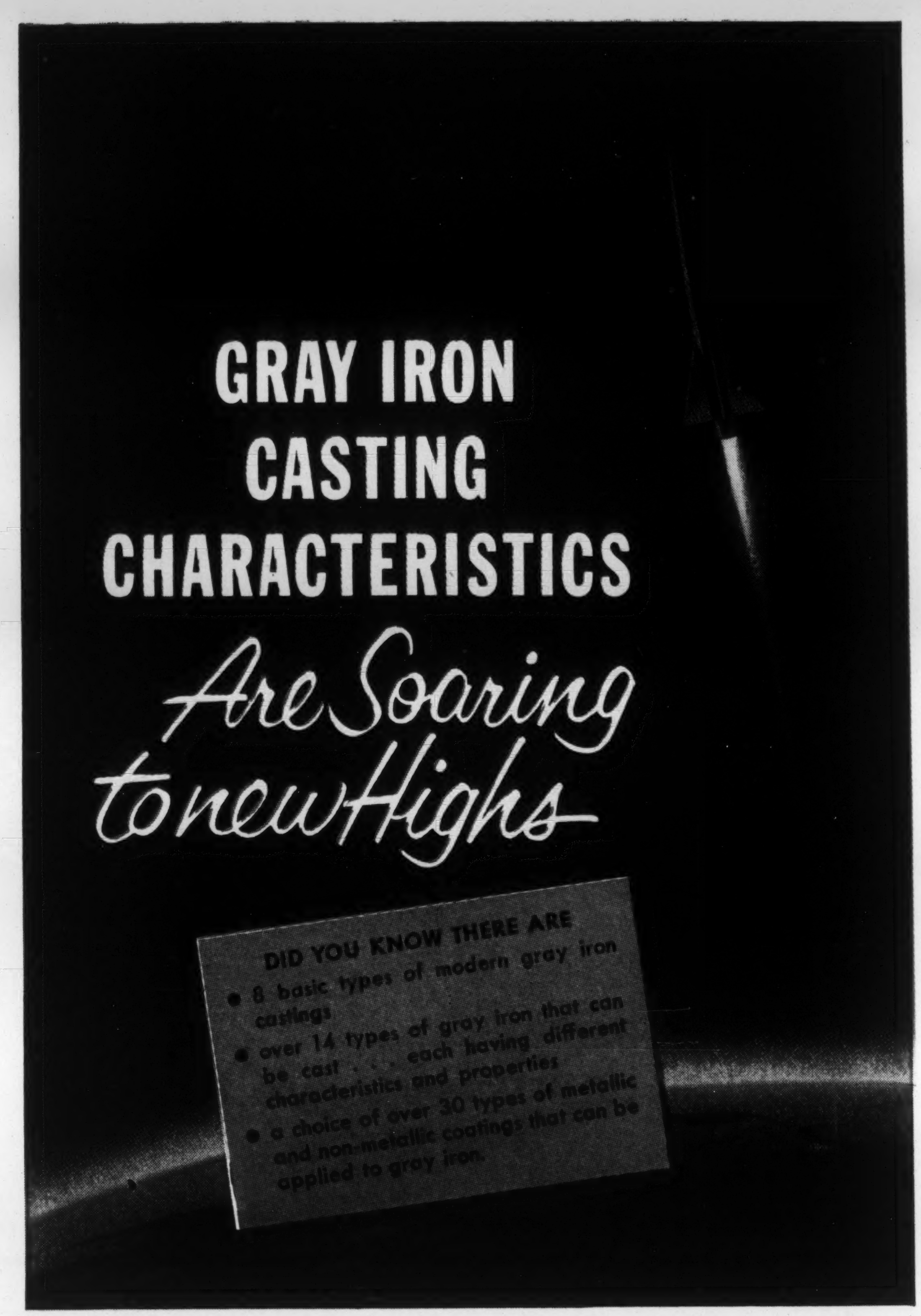


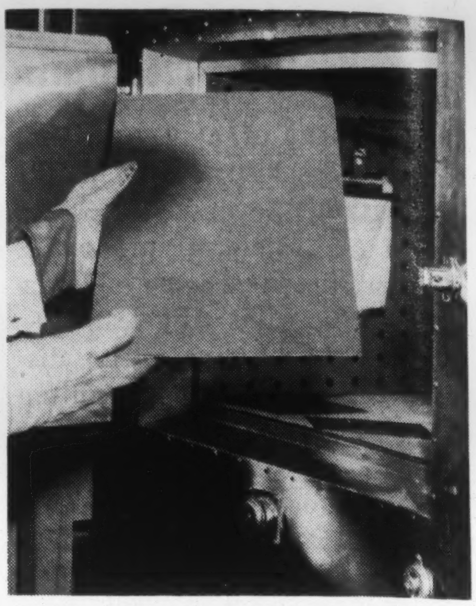
GRAY IRON
CASTING
CHARACTERISTICS
Are Soaring to new Highs

DID YOU KNOW THERE ARE
- 8 basic types of modern gray iron castings
- over 14 types of gray iron that can be cast . . . each having different characteristics and properties
- a choice of over 30 types of metallic and non-metallic coatings that can be applied to gray iron.

If you are on the lookout for new ways and means to improve your products *and save money, too,* investigate modern gray iron castings. Gray iron is not only the most economical of all basic components, but recent developments in new gray irons and casting techniques are elevating their utility to new highs. Today they possess a combination of essential engineering properties that cannot normally be duplicated in more expensive competitive materials. Acquaint yourself with the present and future possibilities of modern, controlled gray irons. Be sure that gray iron is making its full contribution to your products. Write for the GIFS "Summary of Specifications" today.

it's time to design with
GRAY IRON CASTINGS
GRAY IRON FOUNDERS' SOCIETY, INC.
National City-East 6th Bldg. • Cleveland 14, Ohio

For more information, turn to Reader Service Card, Circle No. 602



Vinyl coated panel *is placed in oven to insure good adhesion and adequate surface hardness.*

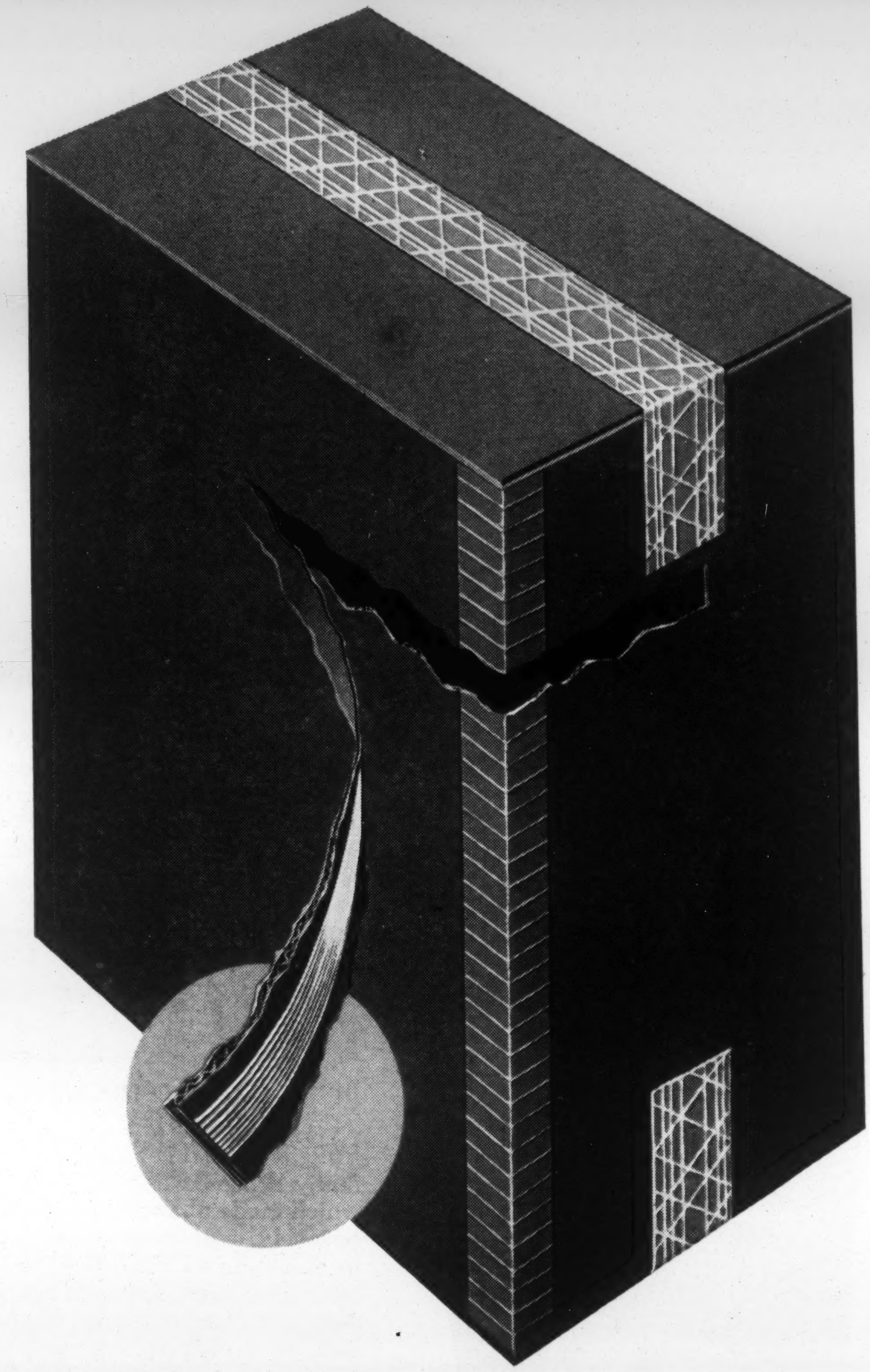
and diisobutyl ketone is recommended for spray application.

The organosol formulation was developed for such applications as coating of sheet stock, machine parts, tool handles, metal ducts, hoods and machine housings.

Styrene Compound Is Heat Resistant

Bakelite Co., Div. of Union Carbide & Carbon Corp., 260 Madison Ave., New York, has introduced an improved high impact, heat resistant polystyrene molding compound called TMD-5161. The compound is said to have a heat distortion temperature considerably higher than that of conventional high impact polystyrene molding compounds. It is designed primarily for electrical appliance housings because of its resistance to breakage and warpage by heat. The molding compound also has good electrical insulation values and is resistant to chemicals.

Characterized by uniformity, versatility, good flow, fast set-up and low bulk factor, the modified polystyrene is said to make possible intricate injection moldings on fast cycles. However, the material has slightly stiffer flow properties than usual, and the



RIP CARTONS OPEN FAST

AVISCO rayon high-strength yarns put cords of extra toughness in all kinds of tapes for quick protective sealing, slash-free opening.

Here's one way high-strength Avisco rayon helps save money and man-hours. Carton opening time is reduced to seconds, and damage to merchandise due to using sharp carton-opening tools is completely eliminated.

Tear tapes, corner stay tapes, and reinforced sealing tapes are just a few of thousands of ways Avisco rayon is used to add strength and tear resistance to packaging materials.

Here are several other examples of how the flexibility, shock resistance and utility of Avisco rayon reinforcements add strength and quality to products at an economical price:

Multi-wall bags for agricultural and chemical products
Case covers and liners · Wrappings for shipping and storing
Wrappings for sheet metals to protect highly finished surfaces
Backing for stucco · Temporary tarpaulins

Whatever your reinforcement requirements, American Viscose can supply fibers and yarns for every application. Our extensive technical facilities and experience are geared to help solve every conceivable design and production problem. Just tell us about your needs on the coupon, and send it in. You'll hear from us immediately.

AVISCO® RAYON

American Viscose Corporation, 350 Fifth Avenue, New York 1, New York

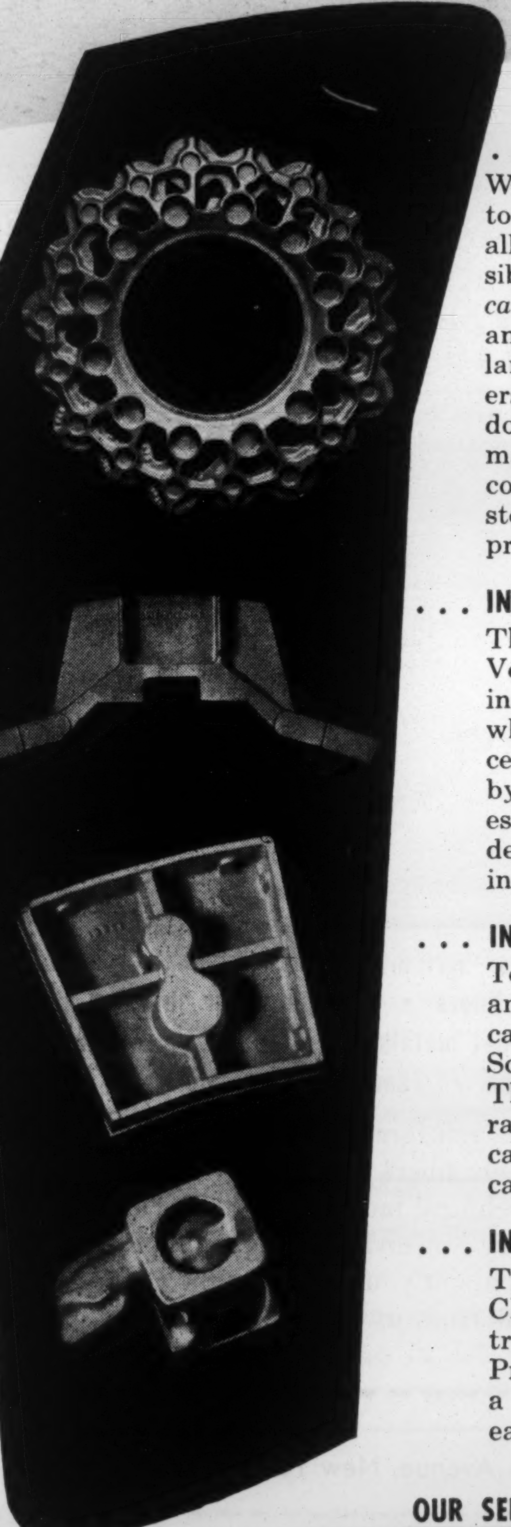
Name ____________________

Name of company ____________________

Address ____________________

Reinforcement requirements ____________________

For more information, turn to Reader Service Card, Circle No. 532



CERAMICAST®*
HAS CHANGED
DESIGN CONCEPTS . . .

. . . IN AIRCRAFT BRAKE SYSTEMS
When aircraft landing speeds became too fast for braking systems of light alloys, CERAMICAST made it possible to produce backing plates in *cast steel* that will stand the stresses and high temperatures placed on the landing gear of today's super bombers and fighters when they "touch down." Backing plate designs of six major U.S. aircraft have now been converted from light alloys to the cast steel of Lebanon's CERAMICAST process.

. . . IN JET ENGINE COMPONENTS
This jet removal track for the Chance Vought F8U-1 *Crusader* was originally designed as a machined part, which made quantity production excessively expensive. Now produced by Lebanon's CERAMICAST process in cast steel, the part retains the desirable characteristics of the original, at a considerable cost saving.

. . . IN THE BOTTLING INDUSTRY
To produce the surface smoothness and close tolerances of this bottling cap guide, engineers at Pneumatic Scale Co. specified CERAMICAST. The thin metal sections and accurately recessed pockets are significant advantages of Lebanon's new casting process.

. . . IN AIRCRAFT FUEL SYSTEMS
The unique advantages of the CERAMICAST process are illustrated in this jet engine fuel valve. Practically impossible to produce as a sand casting, this component is easily adaptable to CERAMICAST.

OUR SERVICE TO YOU
If your design project utilizes cast steel in any form, CERAMICAST may provide quality and cost advantages. Let our engineers discuss the process with you and its applicability to your problems. Write for complete descriptions and applications of the CERAMICAST process.

* CERAMICAST is a registered trademark

LEBANON STEEL FOUNDRY
113 LEHMAN STREET LEBANON, PENNSYLVANIA
CARBON, LOW ALLOY AND STAINLESS STEEL CASTINGS

For more information, turn to Reader Service Card, Circle No. 541

PROPERTIES OF TMD-5161

Specific Gravity	1.04
Heat Distortion Temp (264 psi), F	
⅛-in. Bar	189
¼-in. Bar	192
½-in. Bar	198
Water Absorption (24 hr immersion), %	0.140
Bulk Factor	1.72
Molding Shrinkage, in./in.	0.004
MECHANICAL PROPERTIES	
Rockwell L Hardness	78
Izod Impact Strength, ft-lb/in. notch	2.6
⅛-in. Bar	2.6
¼-in. Bar	1.1
Compressive Yield Stress (½-in. bar) psi	10,300
Tensile Strength (⅛-in. bar), psi	6700
Elongation in Tension, %	5
Mod of Elast in Tension, psi	3.5 x 10^5
Flexural Strength (¼-in. bar), psi	9200
ELECTRICAL PROPERTIES	
Dielectric Strength (short time), v/mil	460
Volume Resistivity, ohm-cm	10^{14}
Dielectric Constant (60 cycles)	2.60
Dissipation Factor (60 cycles)	0.002

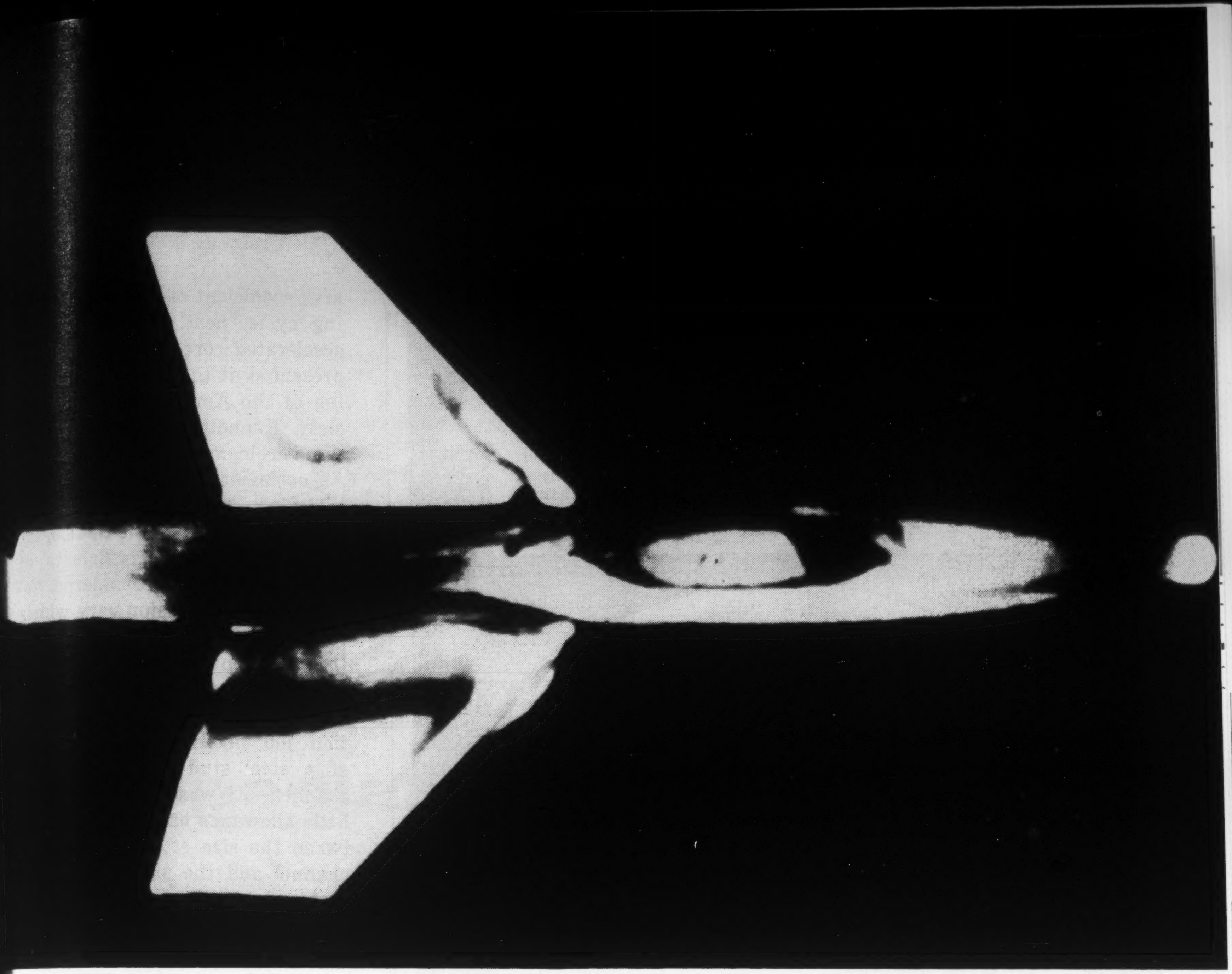
producer recommends a preheat period of 1 hr at 174 F to ensure faster set-up and better quality in the finished product.

According to the producer, the compound is easily molded to provide parts with good mechanical strength and shock resistance, high gloss and good appearance. It is available in a range of colors and is supplied in cylindrical pellets about 0.1 in. in diameter and length.

The material is recommended for such applications as radio cabinets, photographic equipment, electric fan housings, vacuum cleaner parts and air conditioning grilles.

Joining Aluminum to Other Metals

Advanced materials and methods now make it feasible to join aluminum to dissimilar metals without serious limitations. However, some problems are still encountered. The four major factors that must be taken into account



thermal thicket

The thermal barrier which now limits the speed of ultra high speed aircraft can be cracked. Needed: Structural components of elevated temperature alloys. Problems: Finding the right alloys; making them easy to forge and machine with regular production-line tools; maintaining uniformity of physical properties in production lots.

Right now, Carpenter is producing elevated temperature alloys which set new standards for consistent ability to meet tough aircraft specifications, high quality, improved forgeability and machinability. Engine builders find them ideal for many critical parts. Forge shops can work them to closer tolerances, get better finishes that require far less than usual machining. Work goes faster. Rejects are fewer.

You can get the full story of these alloys — their application, fabrication and engineering properties — in the new booklet, "Carpenter Alloys for Elevated Temperature Service". Get your personal copy by writing on your Company letterhead. The Carpenter Steel Company, 135 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service

For more information, turn to Reader Service Card, Circle No. 365

AT Chicago Rivet ALL 3
will reduce your Fastening Costs

RIVETS

rivets

Semi-Tubular, Split and Shoulder

You avoid machine down-time because every semi-tubular, full tubular, split, shoulder or special rivet is precision made and hand inspected to assure free, non-clogging movement in automatic setters.

rivet setters

Your fastening costs are less because Chicago Rivet makes machines that set from one to seven rivets at a time. Riveting is automatic and may involve the use of special indexing fixtures, adjustable riveting centers, and top or bottom rivet feeding and other mechanisms, controlled by solenoids or air cylinders or both.

engineering

The recommendations of Chicago Rivet Engineers are most valuable. Their knowledge of rivet fastening techniques, gained from solving thousands of manufacturers' fastening problems can help make your product more competitive. Calling Chicago Rivet is a habit-formed procedure with many companies. You incur no obligation when you use the service of Chicago Rivet Engineers. Send a blue print or sample assembly with your inquiry.

Chicago Rivet & MACHINE CO.
9628 WEST JACKSON BOULEVARD
BELLWOOD (CHICAGO SUBURB) ILLINOIS
BRANCH FACTORY: TYRONE, PA.

Chicago Rivet RIVETS RIVETS RIVETS

New Rivet Catalog contains engineering data, list of popular semi-tubular, full tubular, split and shoulder rivets and popular automatic rivet setters. Write for copy.

For more Information, turn to Reader Service Card, Circle No. 539

are: coefficient of expansion, heating cycle, heat conductivity and accelerated corrosion. In a paper presented at the annual fall meeting of the American Welding Society, Kenneth V. Lutz discussed these problems and their remedies.

Coefficient of expansion—When soldering, and therefore raising the temperature of the metals, the difference in the coefficients of expansion must be considered. Coefficients of expansion vary widely for different metals. For example, the coefficient (per °F) for iron is 0.66×10^{-5}, compared to 1.33×10^{-5} for aluminum. In a production job involving the soldering of a steel stud to an aluminum channel, it was found that so little allowance had been made between the size of the hole in the channel and the size of the stud that when the assembly was heated to soldering temperature there was, in effect, a shrunk fit between the assembled parts. The solder was not thin-flowing enough to penetrate. The solution to this problem was entirely mechanical: the hole was made slightly larger.

Heating cycle—Fluxes are carefully compounded for special solders. This does not mean that only one flux can be used with only one solder. However, it is extremely important that the active point of the flux correspond to the flow point of the rod. Also, the component chemicals of the flux are balanced for maximum wetting action and minimum injurious fumes. If heat is maintained too long or too slowly built up, the active ingredients evaporate or burn out. This makes the flux ineffective for its purpose and this is sometimes worse than not having any flux at all.

In fabricating aluminum with stainless steel, solder No. 430 is specified. It is a strong solder, producing joints that can withstand a pull of 10,000-28,000 psi depending upon the type of joint. Flux No. 37 is specified for this solder. It is a nonflame flux and

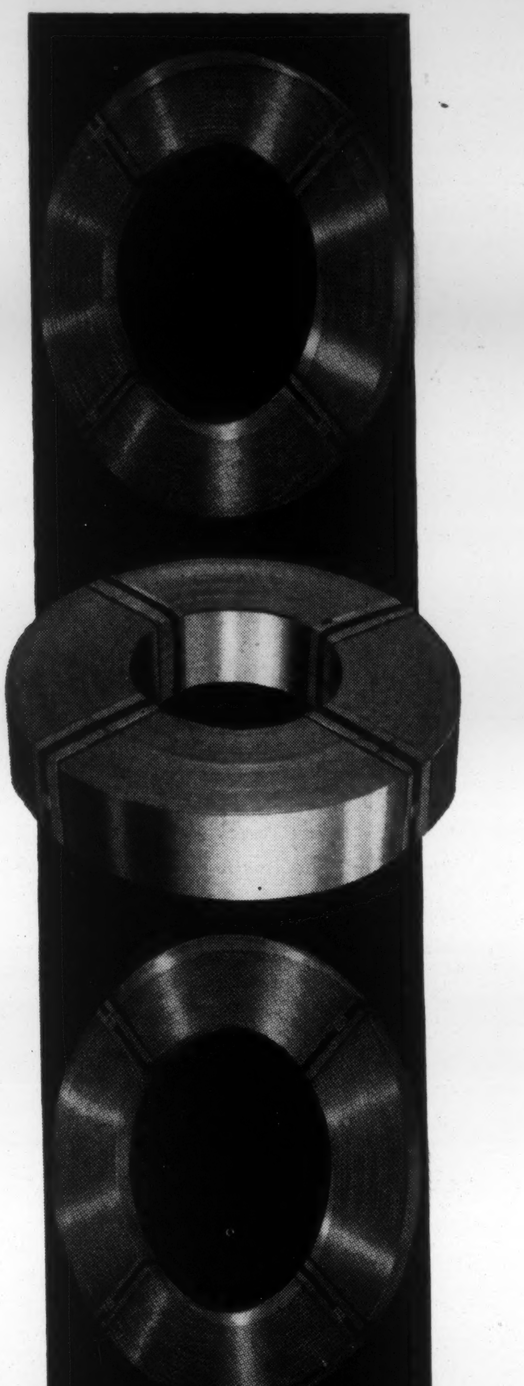
Crucible gives you
wide selection,
dependable delivery of

Cold Rolled Specialty Steels

For a *full* selection of cold rolled specialty steels – call Crucible. Deliveries are on-schedule – in the size, grade, finish or length you need.

And Crucible's new mill facilities mean closer control of rolling . . . insure greater physical uniformity . . . fine finish . . . better edges . . . flatter strip.

Whether you use carbon spring steel, alloy strip steel, or many other ferrous analyses that can be cold rolled, you can't beat Crucible. More information is contained in the 32-page booklet, "Cold Rolled Specialty Steels". Write for your free copy now. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*



CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

For more information, turn to Reader Service Card, Circle No. 522

ideal for wear resistant parts
CHEMISEAL† NYLON

For bearings, gears, cams, bushings, rollers, slides and other mechanical and electromechanical parts where wear resistance is essential—and often where no conventional lubricants, or no lubricant at all can be used —*select Chemiseal Nylon* (*Zytel* 101*). It is not only the best but the least expensive of the standard Nylon compositions.

And this superior Nylon is backed by a fabrication service which is more complete than is provided by any other organization. It offers (1) an almost infinite variety of extruded rods, tubing and special shapes for your own production of parts, (2) high-speed, low-cost facilities for custom-machining precision parts to your specifications and (3) large volume injection molding of parts for the ultimate in production economy.

Send detailed dimensional drawings of parts and quantities required, or write for Bulletin N-1056.

United States Gasket Company
Camden 1, New Jersey

COMPLETE SERVICE
- Extruded rods, tubing, special shapes.
- Custom-machined parts.
- Injection Molded parts to specification.

United States Gasket Plastics Division
OF THE GARLOCK PACKING COMPANY

†U.S.G. trademark
*du Pont trademark

For more information, turn to Reader Service Card, Circle No. 558

is applied with indirect methods of heating. Therefore, the combination may not be used under circumstances where the parts are prefluxed, assembled and brought slowly up to the soldering temperature.

A typical problem involved a furnace application using this 430-37 combination to join aluminum to stainless steel. The belt carrying the prefluxed assembly through the furnace was so slow that all the active ingredients of the flux were gone before the preplaced solder was melted. The solution involved nothing more than speeding up the belt and raising the temperature of the furnace so that all elements of the soldering operation reached the required temperature at the same time.

Heat conductivity—Where heat conductivity problems are encountered in welding, brazing or soldering aluminum to other metals of approximately the same size, it is advisable to play the heat on the part that is the best heat conductor. On differently sized parts, the heat should be played on the largest part. When the problem is complicated by a second soldering operation, the approach is considerably different because the second soldering may melt the first. For every job there are a number of different solders available. The logical solution, therefore, is to select a high temperature solder for the first operation and the lowest possible for the second.

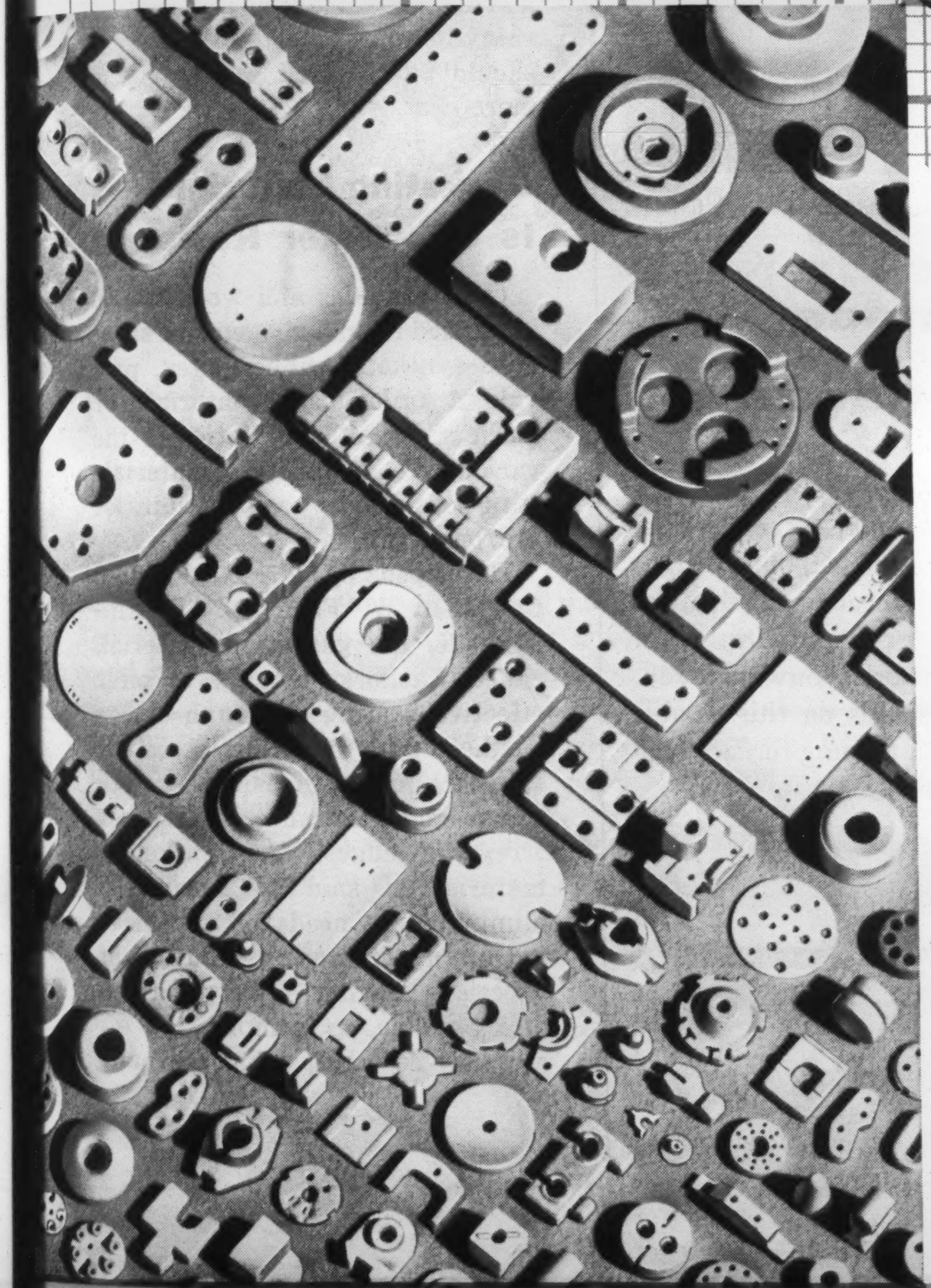
Accelerated corrosion — Flux residue causes accelerated corrosion. Although after-soldering cleaning involves a relatively simple operation of washing with hot water, there are times when this is not practical, e.g., in underground installations of aluminum cable where the cable is joined to copper lugs.

In applications where flux would be detrimental because it

Improves your product. Lowers your costs...

ALSIMAG®

die pressed ceramics



If you need a strong, low cost component . . . custom made for your application . . . with superior electrical characteristics . . . great thermal shock resistance . . . produced to close dimensional tolerances . . . available in volume . . . it will pay you to investigate the "plus" values of AlSiMag pressed ceramics.

Most complete choice of special characteristic materials in the industry, including new and rugged AlSiMag Alumina "super ceramics." Wide latitude in design. Strict Quality Control. Dependable uniformity. Fast deliveries. Batteries of high speed presses. Complete equipment for the most efficient and economical production of parts to specification in any quantity. Ample facilities for volume raw material preparation, firing and machining.

Prototype service available. Check performance under actual operating conditions **before** placing orders for tooling, quantity lots.

Send sketch with detailed specifications for prices and suggestions from our highly specialized Engineering Department on material and design. No obligation.

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AMERICAN LAVA CORPORATION

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55TH YEAR OF CERAMIC LEADERSHIP

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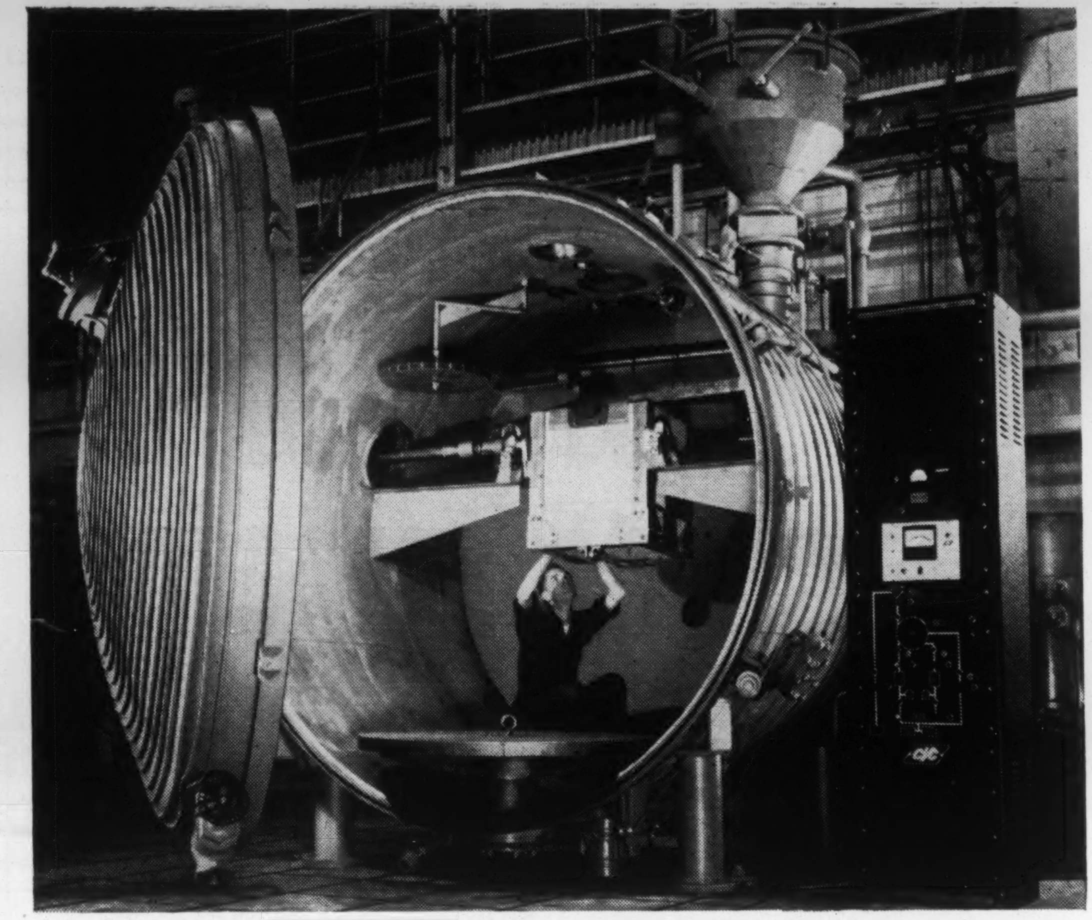
For more information, turn to Reader Service Card, Circle No. 490



CEC's new 300 to 1000 pound vacuum induction melting furnace.

Get a vacuum furnace that *grows* with your needs

Save costly alterations, or the purchase of another furnace, when your requirements change. Make sure you get these features:

Flexible capacity. Expand the furnace's basic 300-pound capacity to as much as 1000 pounds simply by changing the crucible-coil.

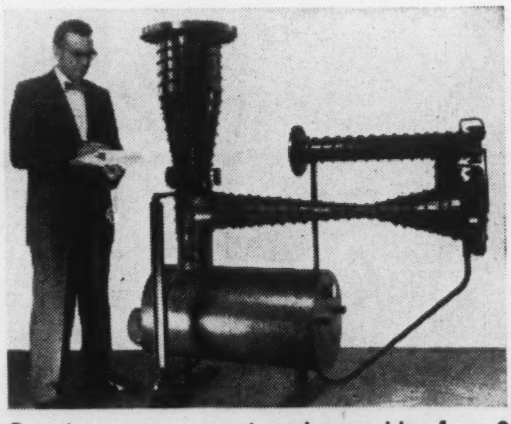
Add an interlock valve to the charging assembly and process as much as 3000 pounds of metal without breaking vacuum.

Flexible pumping system. Add a pump, or switch to larger pumps, and double, triple, even quadruple the pumping system's speed and capacity.

Flexible casting. Cast a single large mold or many small ones; add such accessories as arc hot-topping equipment in ports already provided.

Flexible accessories. All necessary accommodations for a sampler, immersion thermocouple, optical sight tube, vacuum throttling valve, interlock valve for charge addition, or any other accessories you want to add.

For more details on this flexible CEC induction melting furnace send for Bulletin 4-35.



Pumping systems are interchangeable: 1 or 2 KS-2000 (shown here), 1 or 2 KS-4000, or one KS-16,000.

Consolidated Electrodynamics
Rochester Division, Rochester 3, N. Y.
formerly Consolidated Vacuum

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

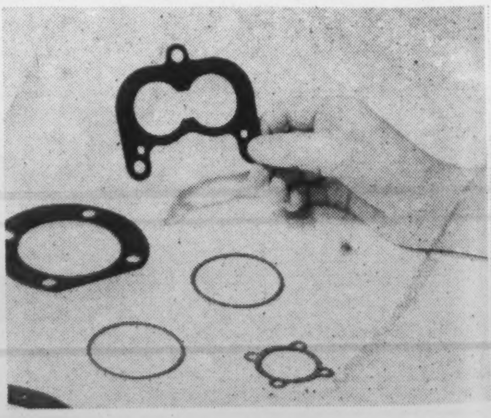
For more information, turn to Reader Service Card, Circle No. 405

is difficult to remove residue, it is often preferable to use a mechanical tinning method. This is easily accomplished by heating the base metal to a point where the solder to be used melts when touched to the base metal. The temperature is maintained and the solder scrubbed into the pores with a clean wire brush. If the solder does not stick to the base metal, leaving a surface that is clean and shiny in appearance, the operation should be repeated using a little more heat.

Gasketing Material Is Oil, Water Resistant

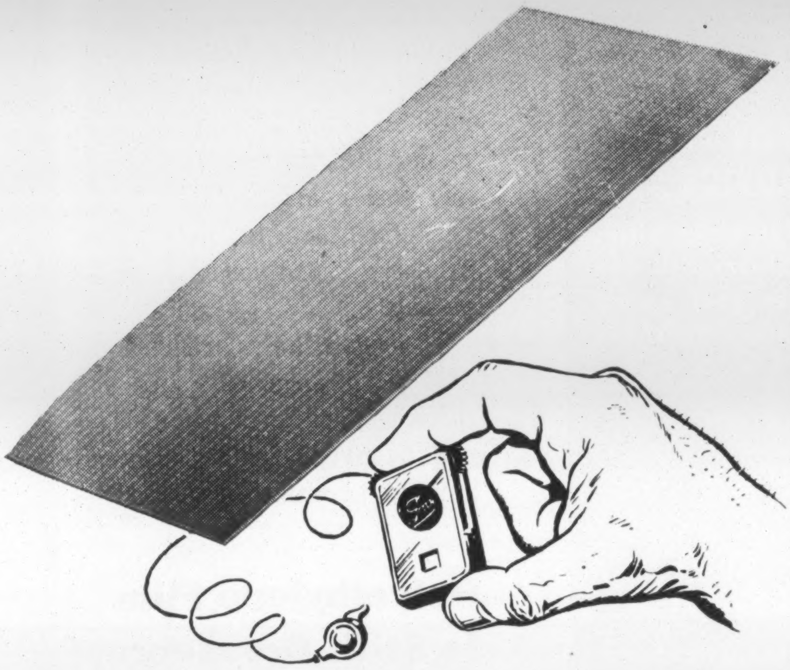
Cork granules and wood fibers, combined in an homogeneous sheet with synthetic rubber latex, provide a tailor-made material for gaskets. By altering ratios of the various components, materials with different compressibilities are possible.

Developed by F. D. Farnum Co., 4940 W. Flournoy St., Chicago 44, the gasketing material, called Kaokork, is said to offer effective seating of rough flange surfaces and to permit seals for thin-sectioned housings with sharp edges. Because it cushions irregular edges, the gasketing material is said to frequently eliminate the need for expensive machining of castings. Design of junctions having fewer bolts is also possible, as compression effectively seals gaps that normally

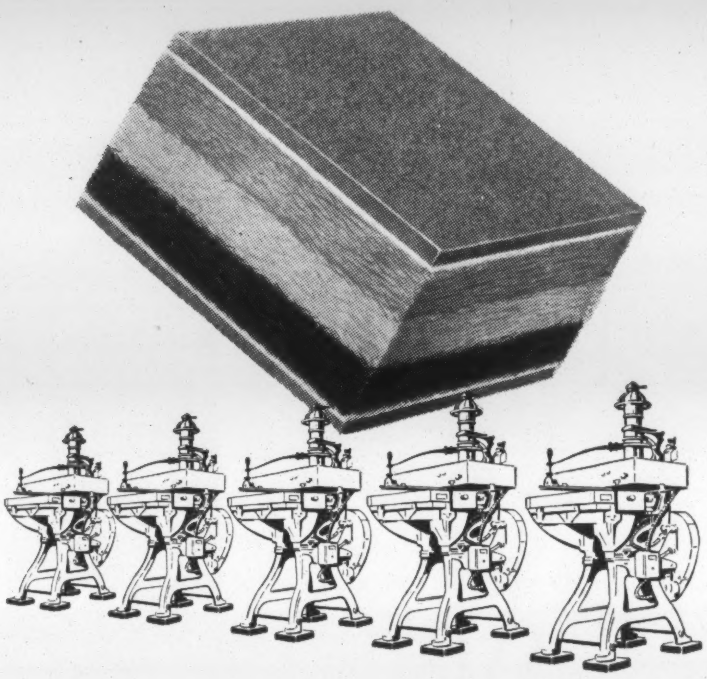


Gaskets *made of wood, cork and rubber can be tailor-made.*

A paper-thin battery separator felt for hearing aids



. . . or Vibra-Mount felts to cut machine vibration*



Put the MAGIC *of American Felts to work for you*

New things are happening most every day at American Felt Company. Exciting things you never dreamed could happen with felts. The battery separator, for example, is made from one of our Feutron** Felts, a combination of synthetic fibers that makes this separator more resistant, longer lasting than the usual material employed.

On the other hand the unusual properties of wool fibers as combined in American's Vibra-Mount Felt eliminate as much as 85% of a machine's vibration, no bolts are needed to fasten machines to concrete or wood floors, "walking" of machines is prevented.

These are just two of the many uses for the felt wonders constantly being produced through the ingenuity of American's Research and Engineering Staff. Use your imagination and many more uses will come to mind.

For the first things in felt it will pay you to call American first. Design with American Felts.

*Trademark Reg. **Trademark Reg.

American Felt Company

TRADE MARK

GENERAL OFFICES: 24 GLENVILLE RD., GLENVILLE, CONN.

SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Greenville, S. C., Dallas, Boynton Beach, Fla., San Francisco, Los Angeles, Portland, San Diego, Seattle, Montreal.—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.

For more information, turn to Reader Service Card, Circle No. 531

CORROSION PROBLEMS SOLVED...COMPLETELY

Tanks . . . Floors . . . Fume exhaust systems . . . anywhere in your plant where corrosion can cause lost time and money, Atlas is prepared to offer their complete service. From on-the-spot technical advice through enginering design to complete construction facilities to carry the job from beginning to end, Atlas can help you with your corrosion problems.

ON THE SPOT TECHNICAL ADVICE

Representatives located in major cities throughout the United States will call at your plant, look over your corrosion problems and prepare suggestions for solving them.

ENGINEERING DESIGN

Engineering facilities at the Atlas home office are geared to provide recommended design features, based on a quarter century of experience in the field.

HIGHEST QUALITY MATERIALS

Atlas time-tested corrosion proof materials of construction are your assurance of long term service. The controlled manufacture of Atlas materials maintains the highest standards of quality.

COMPLETE CONSTRUCTION FACILITIES

The most complete corrosion proof construction facilities available are maintained by Atlas. Shop and field fabrication, installation and follow-up service assures you of complete interest in your problems.

Write for your copy of Atlas Bulletin CC#3 containing informative data on the complete Atlas line.

ATLAS MINERAL PRODUCTS COMPANY
MERTZTOWN, PENNSYLVANIA

For more information, turn to Reader Service Card, Circle No. 577

would require additional fastenings.

The combination of cork granules, wood fibers and nitrile rubber latex is said to provide a gasketing material having good oil, water and solvent resistance, yet maintaining maximum compressive properties and high strength.

It is available in sheet stock up to 100 in. in width and ⅛ in. in thickness. The company is equipped to prepare dies and cut gaskets in production quantities.

Polyethylene Film Is Stiff, Greaseproof

A moderately high density polyethylene resin, recently introduced by Spencer Chemical Co., 610 Dwight Bldg., Kansas City 5, Mo., is said to make possible a film that is two-and-a-half times stiffer, less than half as permeable to gases and water vapor, and at least three times more greaseproof than conventional polyethylene films.

Designated Poly-Eth Hi-D 2504, the resin has a specific gravity of 0.938 and is produced by Spencer's modified high pressure process (see M&M, Oct '56, p 145). It is available in truckload quantities at a price of 47¢ per lb.

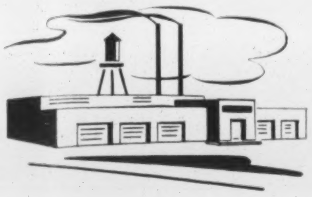
The resin is claimed to make possible a film with a high degree of clarity and good gloss, and

PROPERTIES OF HI-D 2504

Specific Gravity	0.938
Melt Index, gm/10 min	1
Vicat Softening Point, F	235
Ultimate Tensile Strength, psi	
Machine Direction	3050
Transverse Direction	3225
Yield Tensile Strength, psi	
Machine Direction	1900
Transverse Direction	2000
Ultimate Elongation, %	
Machine Direction	455
Transverse Direction	600
Tear Strength, gm/mil	
Machine Direction	93
Transverse Direction	97
Coefficient of Friction	0.6

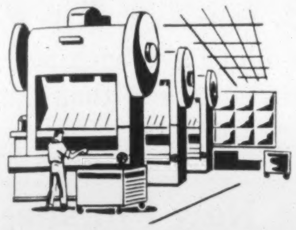
SAVE with BOSSERT METAL STAMPINGS

SAVE ON CAPITAL INVESTMENT



Considering a plant expansion program to produce stamped metal parts or assemblies for your product? Before you invest . . . investigate Bossert as a dependable source for all your stamping requirements. Our facilities and experience can offer you many production economies.

SAVE ON SPECIALIZED EQUIPMENT



At Bossert, we have the modern, highly-mechanized equipment for economical production line operations. Your job can be carried to any stage of completion with our facilities for machining, welding, grinding, plating, annealing and painting.

SAVE ON INVENTORY SUPPLIES

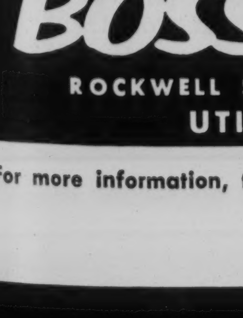
Bossert is geared for both long and short production runs, and you can schedule your job to meet your normal operating requirements or seasonal peak loads without carrying a heavy inventory of parts.

SAVE ON SKILLED PERSONNEL

Bossert has the competent design engineers and experienced metal craftsmen to translate your ideas into cost-saving parts or assemblies. They can often suggest improvements that will make your product more attractive and less expensive to produce.

Large and small parts and assemblies in any metal or alloy . . .

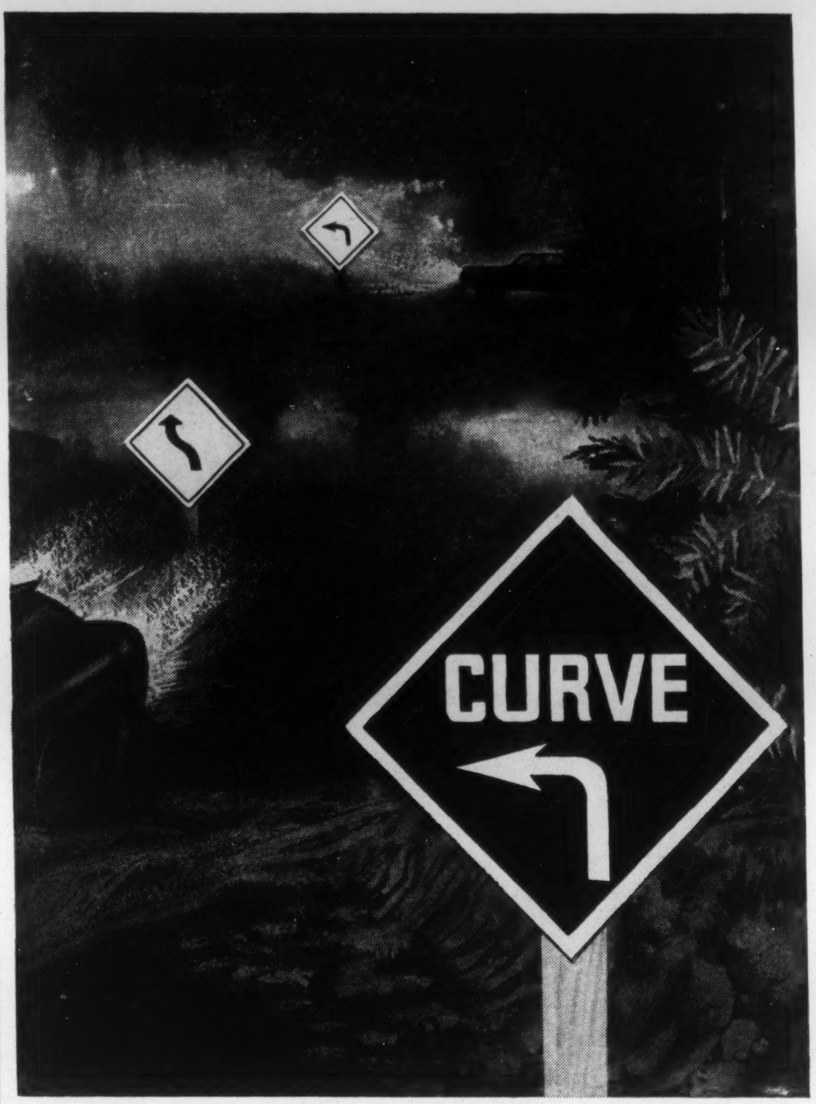
This is a typical group of stampings and assemblies that we are currently producing. We often re-design parts that were formerly cast, forged or machined, at a substantial saving in cost.



Send for illustrated booklet, "METAL STAMPINGS." It describes our design service and production facilities.

BOSSERT DIVISION
ROCKWELL SPRING AND AXLE COMPANY
UTICA 1, NEW YORK

For more information, turn to Reader Service Card, Circle No. 433



Foggy dew on 99 no problem for safety signs of GPX Plastic-Surfaced Plywood and "Scotchlite"

There's a bright future ahead for highway signs of GPX General Use and "Scotchlite" Reflective Sheeting as more and more states replace metal signs. Comparison proves that high density GPX Plastic-Surfaced Plywood actually deters moisture condensation and resists vandalism, sand etching, rain, or hail better than metal. GPX super-smooth surface is an ideal base for reflective sheeting at far lower cost. Don't take chances on safety signs that take chances on human lives . . . insist on GPX.

Free sample on request.

GEORGIA—PACIFIC
CORPORATION

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Please send free sample and literature on GPX.

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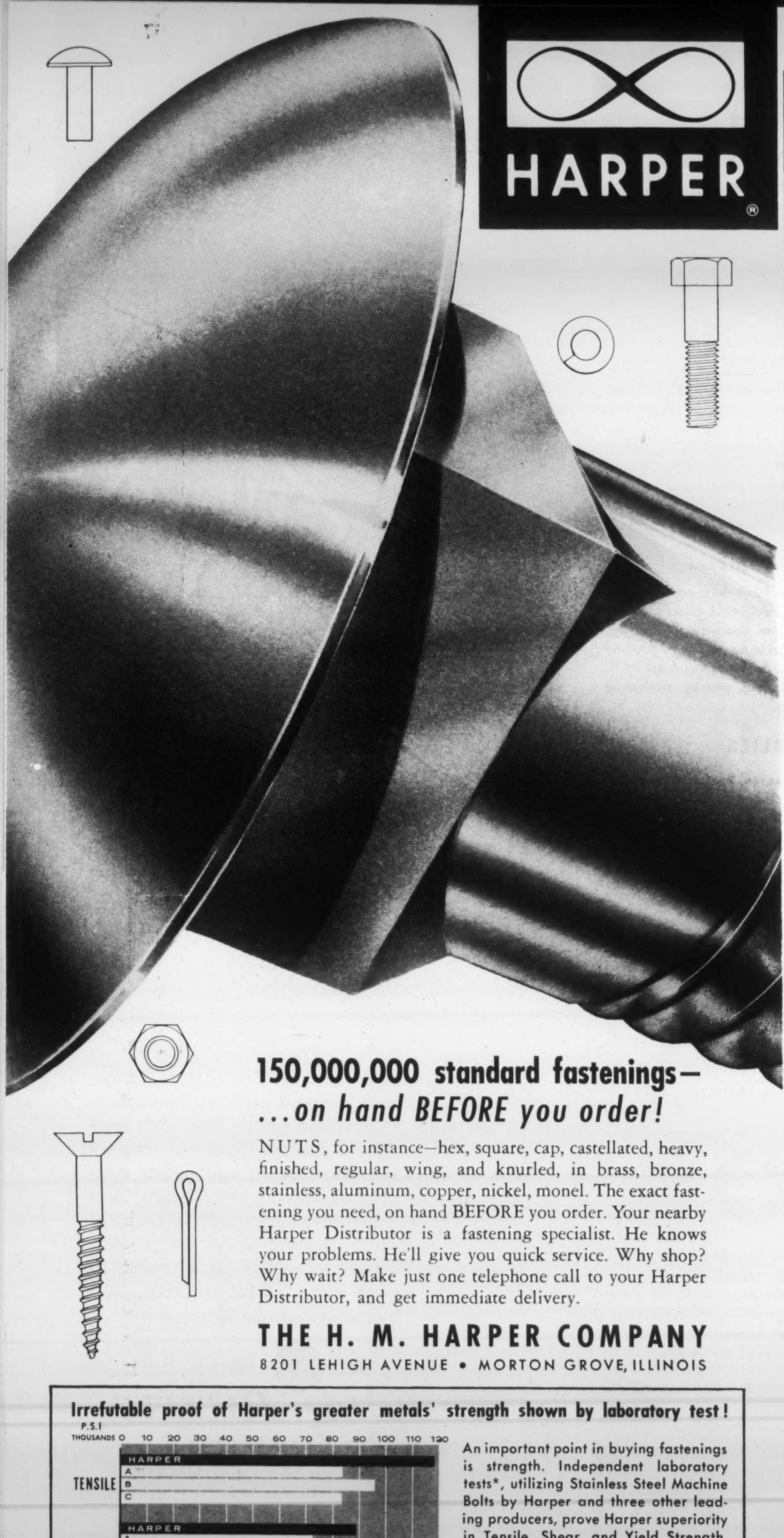
For more information, turn to Reader Service Card, Circle No. 428

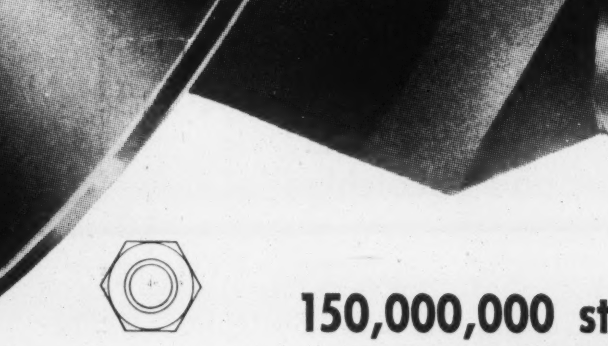


150,000,000 standard fastenings—
...on hand BEFORE you order!

NUTS, for instance—hex, square, cap, castellated, heavy, finished, regular, wing, and knurled, in brass, bronze, stainless, aluminum, copper, nickel, monel. The exact fastening you need, on hand BEFORE you order. Your nearby Harper Distributor is a fastening specialist. He knows your problems. He'll give you quick service. Why shop? Why wait? Make just one telephone call to your Harper Distributor, and get immediate delivery.

THE H. M. HARPER COMPANY
8201 LEHIGH AVENUE • MORTON GROVE, ILLINOIS

Irrefutable proof of Harper's greater metals' strength shown by laboratory test!



An important point in buying fastenings is strength. Independent laboratory tests*, utilizing Stainless Steel Machine Bolts by Harper and three other leading producers, prove Harper superiority in Tensile, Shear, and Yield Strength. The chart at left shows the actual results of these tests. For complete information on these important tests, request Form No. 126.

*By R. W. Hunt Laboratories

greater yield strength than conventional film. Impact strength of the new film is somewhat less than that of conventional film. The film withstands pasteurization and boiling, and it can be heat sealed and printed. Its slip characteristics are said to be superior to those of unlubricated conventional polyethylene films.

The resin can be processed on conventional film-making equipment but requires temperatures roughly 25 °F higher than standard film materials. Both flat and tubular film have been made with thicknesses of less than 1 mil.

Three New Finishes

Recent developments in finishes include white and light colored flow coating enamels and a 22-carat gold ceramic finish.

1. Hammered-effect lacquer

A one coat, fast drying, hammered-effect lacquer enamel called Dulac One-Coat Hammertone has been developed by Maas & Waldstein Co., 2121 McCarter Highway, Newark 4, N. J. It is said to have excellent adhesion to most metals and can be easily applied with a standard spray gun. It is available in a wide range of metallic colors.

2. Flow-coat enamels

Interchemical Corp., Finishes Div., 224 McWhorter St., Newark 5, N. J., has recently announced a line of white and light colored flow coating enamels and primers. The enamels can be used over primers or as one coat finishes on appliances.

Known as IC Ultraflo primers and enamels, the paints are said to flow quickly and completely in the first seconds after application, then undergo an increase in viscosity that causes them to "stay put" around sharp edges and holes. Because of their inherent stability and controlled evaporation rate, the enamels are claimed to change less and require

◄ For more information, Circle No. 491

less control than conventional enamels.

3. Gold ceramic finish

A 22-carat gold ceramic finish, said to be competitive in price with other commercial finishes, has been developed by Bettinger Corp., Gore St., Waltham, Mass. The paint is said to be permanent, since gold is fused into the surface of the ceramic material.

Low cost is possible because only a thin application of gold is needed; the ceramic material makes the finish more stable than the gold itself. The gold finish is presently being used on gasoline pumps.

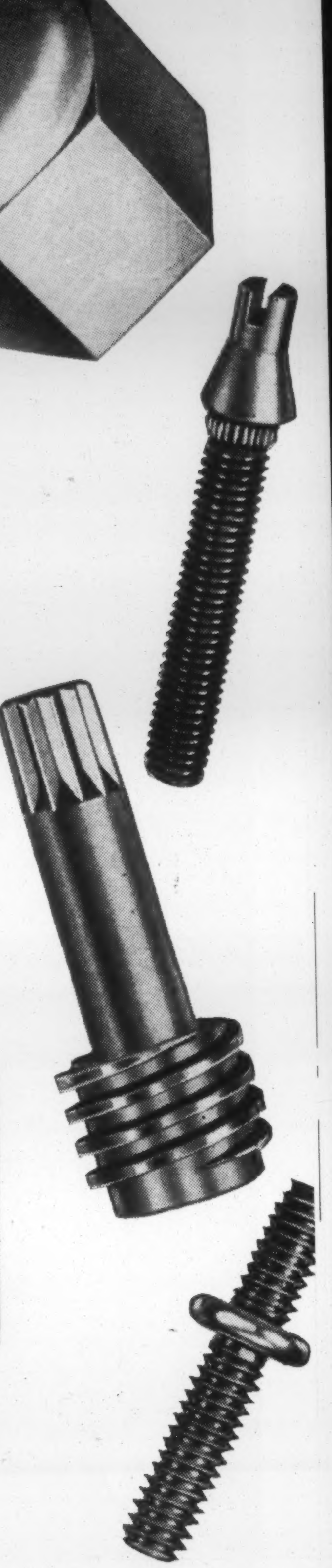
Silicone-Insulated Unit Has Run 14 Years

In a series of tests to determine the minimum and maximum life of silicone insulation in electric motors, a much abused, silicone insulated motor finally broke down after running 60,173 hr. Minimum life was decided some time ago when the high temperatures either oxidized the copper or warped the rotor, of similar motors causing failure while the insulation was still effective.

Started in October, 1943 as a joint project of Dow Corning and Westinghouse, the test used eight

***Lamination slippage** broke down this silicone-insulated, 10-hp motor after it had run 60,000 hr at 464 F.*

For more information, Circle No. 492 ➤



HARPER®

CORROSION-RESISTANT FASTENINGS

Harper FLO-FORM Process
Saved money... made part better!

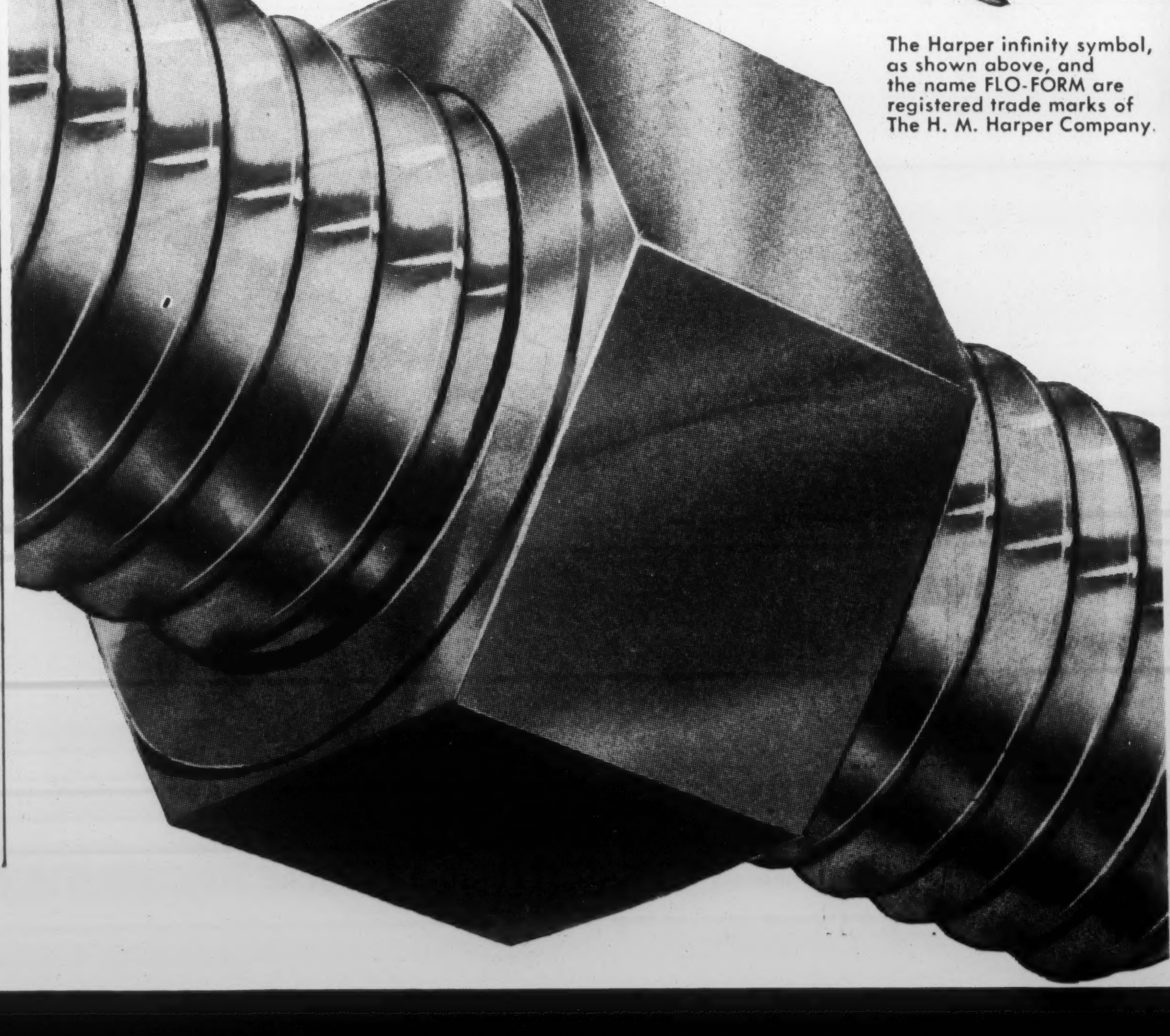
A manufacturer of an electrical hand tool was milling and slotting a copper conductivity pin from wire. The cost was too high—too many rejects. They called in the Harper Application Engineer who suggested redesign of the part for production by the Flo-Form Process. Now it is made at lower cost. There are no rejects. Grain structure is better. The part is stronger and more efficient. Your "special" problem can be solved by the Harper Flo-Form engineering team of designers, metallurgists, and tooling specialists with vast experience gained in over 33 years of solving fastenings problems. Save money. Send us your problem today or call your nearby Harper Branch for Harper Application Engineering Service.

Meet Harper Application Engineer, EDWARD RUSSELL

Fastenings users in Houston and the booming Southwestern industrial empire know the advantages of Harper Flo-Form Engineering Service from their association with Mr. Russell. Ed's vast knowledge and experience in special applications has solved many a tough fastening problem for his customers.

THE H. M. HARPER COMPANY
8201 LEHIGH AVENUE • MORTON GROVE, ILLINOIS

The Harper infinity symbol, as shown above, and the name FLO-FORM are registered trade marks of The H. M. Harper Company.



Brushes—

One of the world's largest lines, with grades for every type of earth-surface or high-altitude motorized electrical equipment . . . for all operating conditions.

. . . backed by over half a century's "know-how" in making carbon-graphite and metallic powder parts that perform the way you want them to!

Contacts

Contact improvement in a given application is seldom a matter of switching to new, more costly materials. More often, as Stackpole engineering has proved, it is only a matter of using contacts produced with the "know-how" of imparting a maximum of desirable characteristics to conventional materials, at the same time minimizing any inherent disadvantages.

STACKPOLE

STACKPOLE CARBON COMPANY, St. Marys, Pa.

For more information, turn to Reader Service Card, Circle No. 418

10-hp, 1190-rpm, 3-phase induction motors. Six motors were insulated with silicone-bonded and impregnated materials and two were Class B insulated.

All eight motors were generator loaded to produce average copper temperatures ranging from 392 to 590 F. Operating time at temperature was divided into "heats" each a 25th of the motor's estimated maximum life. The heats were alternated with 24-hr conditioning periods at 100% relative humidity. Minimum life was defined as the point at which crazing appeared on the varnish surface, and maximum life was defined as actual insulation failure.

Both Class B units failed and caught fire, as expected. One Class B unit ran 3760 hr at a temperature of 392 F before failure; the other ran 1056 hr at 527 F before failure.

Five silicone insulated motors failed at various times and temperatures. One motor ran 5131 hr at 590 F before breaking down. Another motor, still operating in January 1957, has so far run a total of 61,500 hr at 464 F.

The test revealed that the "failure mechanism" of silicone insulation was far different than that of organic materials. After the varnish had crazed, silicone insulation still maintained a good bond, holding the other components in place. It never evolved into a conductor because of its silica backbone, and it stayed hydrophobic.

Lead and Polyethylene Make an Atomic Shield

A lead-filled thermoplastic compound containing 95% lead and 5% polyethylene by weight is available from Telectro Industries Corp., 35-18 37th St., Long Island City 1, N. Y. Called Leadolene, the material melts at a temperature of 220 F. It can be used for

Facts to consider when you're buying

Chromate Conversion Coatings

for Corrosion Protection, Paint Base, Decorative Finishing

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002″ max.) gel-like, complex chromate film of a nonporous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

If your company is manufacturing or buying parts or complete assemblies made from or plated with any of the more common non-ferrous metals—zinc, cadmium, aluminum, magnesium, silver, copper, brass or bronze—you've probably already run up against the question of finishing these surfaces with a chromate conversion coating. These coatings are used to protect against corrosion, or to provide a base for paint or to provide a decorative finish for sales appeal or shelf life. Since chromate conversion coatings represent a relatively new means of obtaining these finishes, this digest of facts to consider may be of value to you.

1. THE COATINGS THEMSELVES. There are many brands on the market. All are similar in many ways. Each, of course, offers its own specific advantages and these may relate to operating techniques, performance under actual use conditions, cost, availability, etc. Naturally, you'll want to choose a coating that is widely known and accepted under both military and civilian specifications.

2. THE COMPANY BEHIND THE PRODUCT. Is it a reliable, established organization? Does it offer experienced technical service, both from the field-engineering organization as well as the home office and laboratories? The man who sells and services your installation should be thoroughly familiar with not only chromate conversion coatings and their applications, but also with the characteristics and performance of related finishing operations such as pre-cleaning, electroplating, painting, etc. This is most important since all steps of the finishing cycle must be functioning properly for the satisfactory performance of the ultimate finish produced.

3. AVAILABILITY OF THE PRODUCT. Ideally, of course, the material should be readily available to you from nearby warehouses to avoid time loss in long distance shipping and to provide emergency service, should the need arise.

4. COST. Naturally, the initial price of the material is important to you. However, just as you consider ultimate cost when you are buying mechanical equipment, ultimate cost must be considered for these finishing chemicals. So, it will pay you to investigate consumption costs, labor costs and the other factors which go into the determination of ultimate cost. Further, cost alone gives no indication of product performance, so careful attention must be given to the purpose the finish must serve and the value that finish will add to your product.

5. FACILITIES FOR RESEARCH AND DEVELOPMENT. Perhaps the existing types of chromate conversion coatings do not include a compound that will accomplish exactly what you wish. Then, it is important to deal with a supplier who has adequate research and development facilities available to work with you to produce a material to meet your needs. Naturally, such a project is seldom completed overnight. But, with complete cooperation and confidence from both you and your supplier, chances are a satisfactory program can be completed.

These are the concepts of sales and service on which we, Allied Research Products, Incorporated, have developed and marketed the line of Iridite chromate conversion coatings . . . superior product performance, complete sales and technical service, easy product availability, economical cost, extensive research and development facilities. No doubt you are familiar with our line and have seen this trademark—

IRIDITE®

—in our advertising, technical literature or on shipping containers in your plant. Remember this trademark when you're buying or investigating chromate conversion coatings for your company. It's your assurance of quality, economical products from a reliable and established company, skilled sales and technical service from both our home office and a national network of representatives, immediate availability from warehouses in strategic industrial areas and our willingness to work with you to develop new finishes to meet your needs, should the present line fall short.

For complete information on Iridite chromate conversion coatings, write today for your free copy of our technical data file. Or, for immediate advice, call in your Allied Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

ALLIED RESEARCH PRODUCTS
INCORPORATED
4004-06 E. MONUMENT STREET • BALTIMORE 5, MD.

Manufacturers of Iridite chromate conversion coatings for corrosion resistance, paint systems, final finishing of non-ferrous metals; ARP Plating Brightener & Chemicals. West Coast Licensee—L. H. Butcher Co.

For more information, turn to Reader Service Card, Circle No. 436

This PE extrusion made with a triple port, 4 mandrel die. Quality control assured because dies and extrusions produced in our own shop.

You are assured — a highly efficient ALUMINUM EXTRUSION SERVICE

PE facilities are complete from billet casting to finished extrusion and include the latest methods of scientific quality control. Our sole business is to produce high quality extrusions promptly at a reasonable price.

This PE specialization in producing aluminum extrusions (neither fabricating or manufacturing other products) is your assurance of immediate skilled attention to your inquiries. We can serve you promptly, efficiently, and at low cost on either standard shape or especially designed extrusions.

PE engineers have wide experience in all types of fabricating operations and can provide invaluable aid in helping create new aluminum extrusion applications that will cut manufacturing costs and improve product quality. Your inquiries receive personalized and confidential attention.

Write for Free Copies PE Extrusioneering News

New illustrated bulletin covers case studies of cost-cutting extrusion applications, includes helpful technical data for design engineers and purchasing executives and gives further facts on PE facilities.

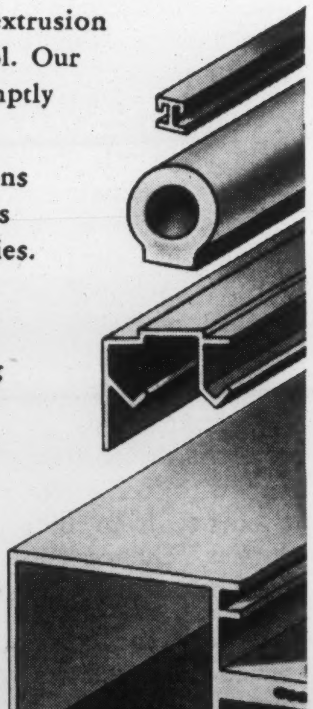
SIMPLE, COMPLEX — LARGE OR SMALL

You'll find PE thoroughly experienced and well equipped to produce almost any type or size extrusion to serve your needs. There are over 5 000 standard PE shapes to select from—without a die service charge. PE Extrusioneering provides the answer for especially designed shapes.

PRECISION EXTRUSIONS, INC.
727 E. GREEN AVENUE BENSENVILLE, ILLINOIS
PHONE: BENSENVILLE 98 • CHICAGO TUxedo 9-1701

Chicagoland's Oldest Aluminum Extruder

For more information, turn to Reader Service Card, Circle No. 503



simple castings. Cast pieces can be remelted and cast again with no loss of material due to oxidation.

The high lead content is helpful in shielding against beta and gamma rays, and the hydrogen in the polyethylene aids in shielding against neutrons. Hydrogen can be increased by changing the ratio of polyethylene to lead. Specific gravity of the final compound can be controlled by changing the ratio of lead and polyethylene in accordance with specific requirements.

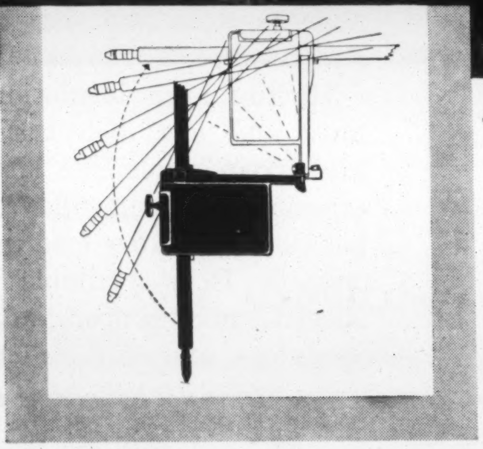
The material is not soluble in most solvents at room temperatures, but at temperatures above 180 F it is readily soluble in either aliphatic or aromatic hydrocarbons. It is soluble to a small degree in hot ester type solvents and high molecular weight alcohols. It cannot be joined by glue or adhesives, but only by melting the edges together or by pouring the liquid lead-polyethylene material into joints or between interlocking members.

Tensile Ductility of Swaged Chromium

D. J. Maykuth and R. I. Jaffee, of Battelle Memorial Institute, have compared the properties of iodide chromium and chromium-base alloys in bar form with those previously reported for strip. They found that swaged and recrystallized (nonfibrous structure) chromium-base alloys with 50% iron or nickel, tested as bar stock, have excellent tensile ductility; but ductility becomes low at 40% iron and is lost at 40% nickel. The investigators also determined that swaged chromium must have a fibrous structure for optimum tensile ductility.

The modulus of elasticity was found to be 42 million psi at room temperature, decreasing to 36 million at 1472 F. This particular

AIRCO
HELIWELD AUTOMATIC HEAD
CONTROL PANEL
AIRCO
HELIWELD
AUTOMATIC
HEAD



New Airco Model C Heliweld automatic head operates at all angles from horizontal to vertical.

Airco introduces New Automatic Heliweld Head for long-run production welding

The Model C Heliweld automatic head is specifically designed for long-run production on regular or irregular contours – aluminum tubing, motor stators, irregularly-shaped pressure vessels. Its prime advantage is that once the required arc length is set the head will automatically maintain this distance by moving the holder up or down to follow the contours of the work piece. Other benefits are:

- **Versatility** – unit provides good arc voltage control using either argon or helium shielding gases or mixture of both.
- **Adaptability** –the head can be operated at all angles from the horizontal to the vertical (normal) position. The maximum raise-lower distance of the electrode holder is a full 16″.
- **Flexibility** – the assembly can be used for AC or DC welding, with or without filler-wire. Electrode diameters range from .020 to 1/8″.

The use of the new automatic head will be required where welds of consistent dimensions and quality are important and where good weld appearance is necessary or where welding specifications are very high for the electrical, aircraft, and refrigeration industries. Complete information covering the wide range of applications and detailed specification data is available. Write Airco at the first opportunity.

AT THE FRONTIERS OF welding PROGRESS YOU'LL FIND . . . AN AIR REDUCTION PRODUCT

VISIT OUR BOOTH 334 WELDING SHOW
APRIL 9-11, 1957 • PHILADELPHIA, PA.

AIRCO®
Offices in most principal cities

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated, New York 17, N. Y.

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In Cuba –
Cuban Air Products Corporation
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Air Reduction Canada Limited

Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide, liquid-solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetates, alcohols, and other synthetic resins.

For more information, turn to Reader Service Card, Circle No. 538

Solve difficult lubrication problems...

PERMANENTLY!

-with

morganite

SELF-LUBRICATING

BEARINGS

- REQUIRE NO OIL OR GREASE
- ARE NON-CONTAMINATING
- FUNCTION IN HIGH TEMPERATURES
- OFFER IMMUNITY TO CORROSION

Morganite Bearings with "built-in" lubrication offer a dependable solution to lubrication problems in aircraft fuel pumps and meters. In boiler, furnace or oven equipment they operate at full efficiency in high temperatures. They are ideal for sealed mechanisms or where inaccessibility makes ordinary methods of lubrication impractical. Morganite is non-corrosive, functions smoothly and efficiently when immersed in water, acids, or alkalies.

Simplify Design with Morganite — Self-lubricating valves, slides, seal noses, rotary vanes, gland and piston rings, pump vanes and other parts are available to specifications. Write to Morganite for engineering data and recommendations on your particular requirements.

OVEN HALF BEARING

BEARING SEAL

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TRADE MARK

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...FOR OVER HALF A CENTURY

Manufacturers of Fine Carbon Graphite Products including Carbon Specialties, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts
Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

For more information, turn to Reader Service Card, Circle No. 453

range was studied because it was felt that there was a lack of accurate data over the temperature range of interest in gas turbines.

This information was originally presented at the 38th annual convention of the American Society for Metals.

Phenolic Laminate Punches Clean, Sharp

A paper-base phenolic laminate with good cold punching and cold shearing characteristics has been developed by Synthane Corp., Oaks, Pa. The new grade, called P-25, is said to eliminate the need for heating equipment and shrinkage allowances because it punches clean and sharp at room temperature.

Having high insulation resistance and low dielectric loss at high frequencies, the laminate is especially recommended for copper-clad laminates used in printed circuits. It is available in plain sheet form or copper-clad, in both semigloss and dull finishes.

(more What's New on p 218)

PROPERTIES OF P-25

PHYSICAL PROPERTIES	
Tensile Strength, psi	
Lengthwise	12,400
Crosswise	9500
Compressive Strength, psi	
Flatwise	25,000
Edgewise	—
Mod of Elasticity in Flexure, psi	
Lengthwise	1,000,000
Crosswise	700,000
Shear Strength, psi	11,000
Izod Notched Impact (edgewise), ft-lb/in.	0.30
Specific Gravity	1.30
Coef of Thermal Expansion, per °F	2×10^{-5}
Water Absorption (24 hr), %	
1/16 in.	1.00
1/8 in.	0.75
ELECTRICAL PROPERTIES	
Dielectric Strength (perp to lam, short time), v/mil	
1/16 in.	200
1/8 in.	150
Dissipation Factor (1 mc)	0.030
Dielectric Constant (1 mc)	4.6
Max Constant Operating Temp, F	250

For more information, turn to Reader Service Card, Circle No. 423

Cut Finishing Costs
THROUGH INCREASED PRODUCTION

AUTOMATIC MACHINES
Increase production hundreds to one over hand methods. Reduce labor costs. Eliminate need of experienced workmen.

CLAMPS AND FIXTURES
Positive pressure and exact registration of the part in the mask. Reduce rejects. Free both hands for productive movements.

SPRAY PAINTING MASKS
A competent engineering staff will counsel with you on the most efficient technique for handling your particular requirements.

MASK WASHING MACHINES
50% faster than any other make. Cut solvent consumption. Avert production delays due to damaging of masks by hand scrubbing.

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CORPORATION
386 TOLEDO FACTORIES BUILDING TOLEDO 2, OHIO

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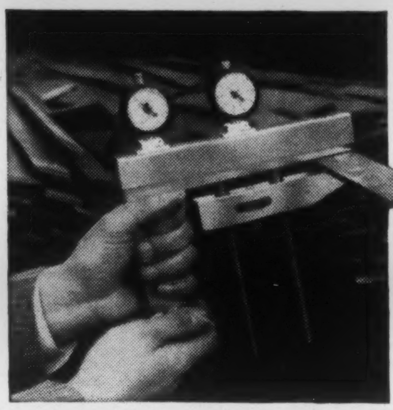
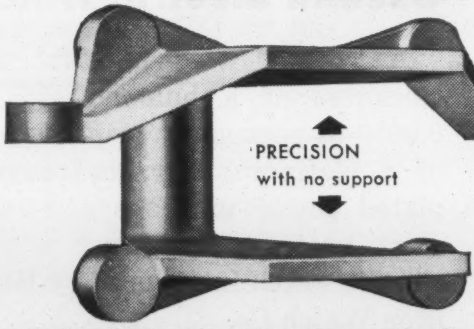


"Bench model" accuracy with a . . .
PORTABLE HARDNESS TESTER

Proof in your plant! A Riehle sales engineer will show you — on certified calibrated specimens — that you *can* get readings with a Riehle portable that are comparable in accuracy to a Rockwell bench-mounted tester. He will also let you make some tests on some of your own materials. You can see first hand how this portable saves the trouble of transporting unwieldly pieces to a bench tester. Write today for free demonstration to Dept. MM-457.

Riehle TESTING MACHINES
A DIVISION OF
American Machine and Metals, Inc.
EAST MOLINE, ILL.

Indian Rope Trick
OPC VERSION!



Those Indian fakirs who suspend ropes in the air without visible means of support have nothing on Ohio Precision Castings! On this aluminum casting, an extremely close tolerance is held between two planes—at the unsupported end of the casting.

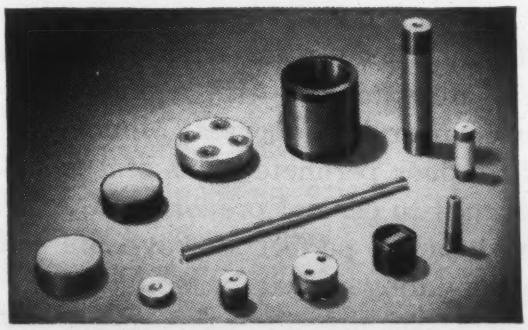
But there's no trick to it—difficult assignments like this are routine at OPC. Maintaining close tolerances on intricately detailed work, and providing a smooth finish that eliminates all or most machining time, are yours automatically when you specify OPC castings.

Our illustrated brochure shows how it's done and includes several interesting examples of small parts production savings in many industries. May we send you a copy?

OPC
OHIO PRECISION CASTINGS, INC.
109 Webb St. • • • • • DAYTON 3, OHIO
Plaster Mold Castings made from
BRASS • BRONZE • ALUMINUM • BERYLLIUM COPPER

For more information, turn to Reader Service Card, Circle No. 430

another first!
MOLCOTE *metallized ceramic coating*
•
•
•
for use with all types of hard solders!



Here's a firmly bonded metal-to-ceramic coated surface to which a metal or metallized ceramic may be hard soldered *up to 2200° F!* Its versatility permits use in a wide latitude of high temperature assembly manipulation, and its extreme refractory qualities defy the attack of solders of the copper-silver, silver, and pure copper types. No expensive preliminary processing is required. MOLCOTE's solder bonds are exceptionally strong to the point of fracture! Like to know more? Bulletin 1155 contains all the facts. Write for a copy!

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84 Muirhead Avenue • Trenton 9, New Jersey
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For more information, turn to Reader Service Card, Circle No. 427

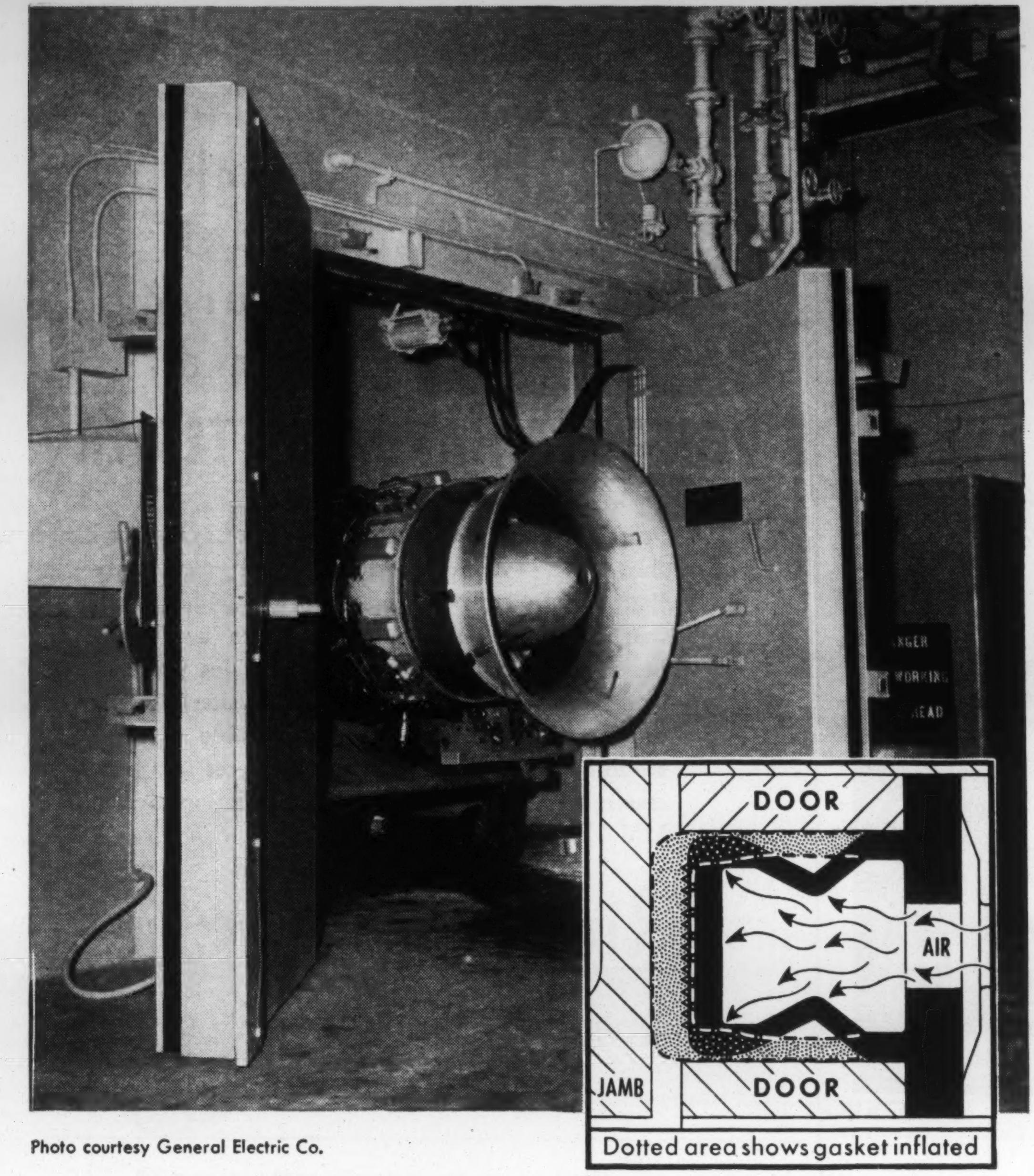


Photo courtesy General Electric Co.

Dotted area shows gasket inflated

Pneumatic Rubber *Door Seal* Muffles Test Cell Noises

To more effectively suppress noise, General Electric jet engine test cells are equipped with a unique pneumatic rubber door seal. Mounted on door perimeter, this seal is designed to expand proportionally and insure a perfect seal over its entire sealing surface *including the corners.* Not only does this gasket dampen the noise but it permits more accurate testing through quieter working conditions.

Continental engineers developed this pneumatic gasket for this and similar applications. Compounded of special flex-resistant rubber, this versatile gasket can be operated with intermittent flexing cycle *or* as a continuous seal—can be adapted to various other types of doors—for *either* pressure or vacuum rooms.

The design of this gasket typifies the engineering skill offered by Continental. When you need "engineered rubber parts"—molded or extruded—enlist the service of specialists—consult Continental.

Engineering Catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1985 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

For more information, turn to Reader Service Card, Circle No. 571

What's new IN MATERIALS

Creep Tester Holds Strain at Same Point

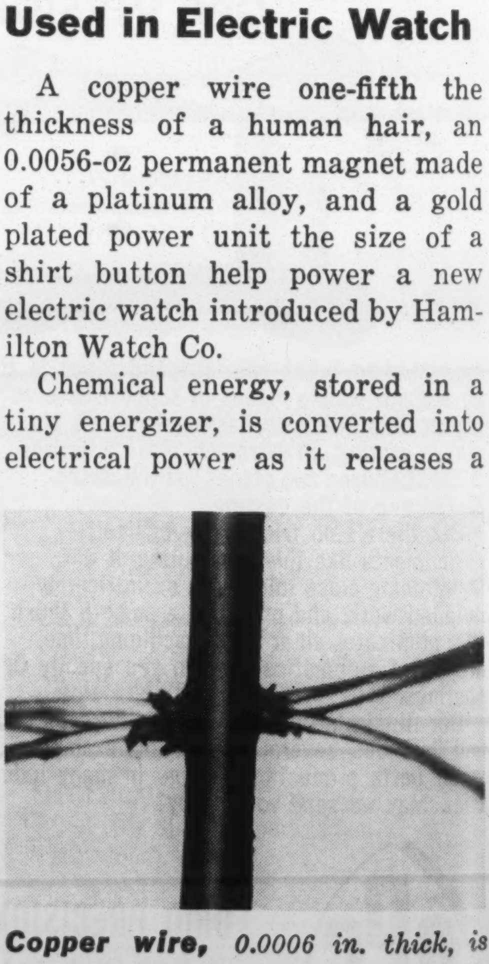
A new creep-strain tester that is said to automatically maintain a fixed extension of the specimen at elevated temperatures has been introduced by Tinius Olsen Testing Machine Co. Operating on a principle directly opposite to that of ordinary creep testers, the machine is started at a desired loading speed and load is applied to the specimen until the predetermined extension is attained. As the specimen tends to strain further, the amount of load is automatically reduced to maintain fixed extension.

A circular testing furnace, mounted between the crossheads of the tester, can be used for testing at any temperature up to 2000 F. A separate unit contains temperature controls and an automatic recorder.

Very Thin Copper Wire Used in Electric Watch

A copper wire one-fifth the thickness of a human hair, an 0.0056-oz permanent magnet made of a platinum alloy, and a gold plated power unit the size of a shirt button help power a new electric watch introduced by Hamilton Watch Co.

Chemical energy, stored in a tiny energizer, is converted into electrical power as it releases a



Copper wire, *0.0006 in. thick, is shown being strung through a hole bored in a human hair.*

Cleaning Specialists*

*[SPE´CIAL·IST—One who devotes himself to some special branch of activity.]

At Northwest our "special branch of activity" is solving your cleaning problems.

Behind your friendly, competent Northwest Sales Engineer stands a reputation for providing industry with low-cost, analytically-correct, job-adjusted chemical cleaners.

From Northwest's years of experience in formulating the RIGHT cleaner for your specific needs have come such developments as the LO-HI pH PROCESS—for cleaning prior to plating, painting, or vitreous enameling; ALKALUME PROCESS—for preparing aluminum and magnesium for finishing and spot welding; INTERLOX PROCESS—for phosphate coating; SPRA-LUBE—to control over-spray of "today's" paints in water wash paint booths; PAINT STRIPPERS—specific to your needs; SUPER-DRAW & FLUID FILM—for drawing metals.

Remember—YOUR COST PER FINISHED ARTICLE IS THE TRUE COST OF YOUR CLEANER.

Northwest's production-tested chemicals and "Right the first time" recommendations will save you money. Northwest Service is as close as your phone.

NORTHWEST CHEMICAL CO.

9310 ROSELAWN DETROIT 4, MICH.

Pioneers in pH cleaning control [illegible] serving you since '32

For more information, turn to Reader Service Card, Circle No. 366

Creative Papers from Mosinee
...are custom-tailored to specific needs...particularly plastic makers'

Paper times a flare to insure safety margins

LAKESIDE RAILWAY FUSEE CO. makes the flares used to warn a train "someone's on the line" ahead. Doing the job well involves considerably more than pouring flammable chemicals into a paper tube. For example, the paper tube itself must burn at a pre-determined rate. Too fast, and there's no receptacle for the chemicals. Too slow, and the paper tube forms a chimney that hides the light of the flare.

Problem — who can develop and make paper that's predictably combustible.

MOSINEE! For 30 years Mosinee has been creating special sulphate papers just to meet such unusual needs. And they may be able to do the same for you. Mail the coupon and see.

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MOSINEE PAPER MILLS CO., Dept. MM-4, Mosinee, Wisconsin
Please furnish details on how you can create special papers to meet our needs.
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PRODUCT
ADDRESS
CITY ZONE STATE

For more information, turn to Reader Service Card, Circle No. 565

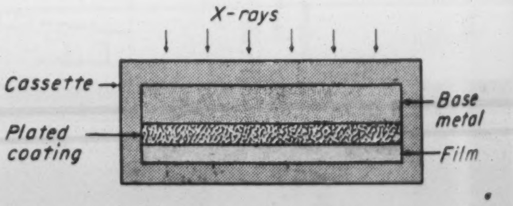
stream of electrons through a coil of fine copper wire fixed on a balance wheel. The electrical energy, through interaction with permanent magnetic fields, causes the balance wheel to oscillate, providing the mechanical energy that runs the watch.

The tiny energizer eliminates the use of a mainspring and is said to be able to run the watch for more than one year at an accuracy greater than 99.995%. The electric watch has about one-third fewer parts than present day automatic watches.

Radiation Detects Pores in Electroplates

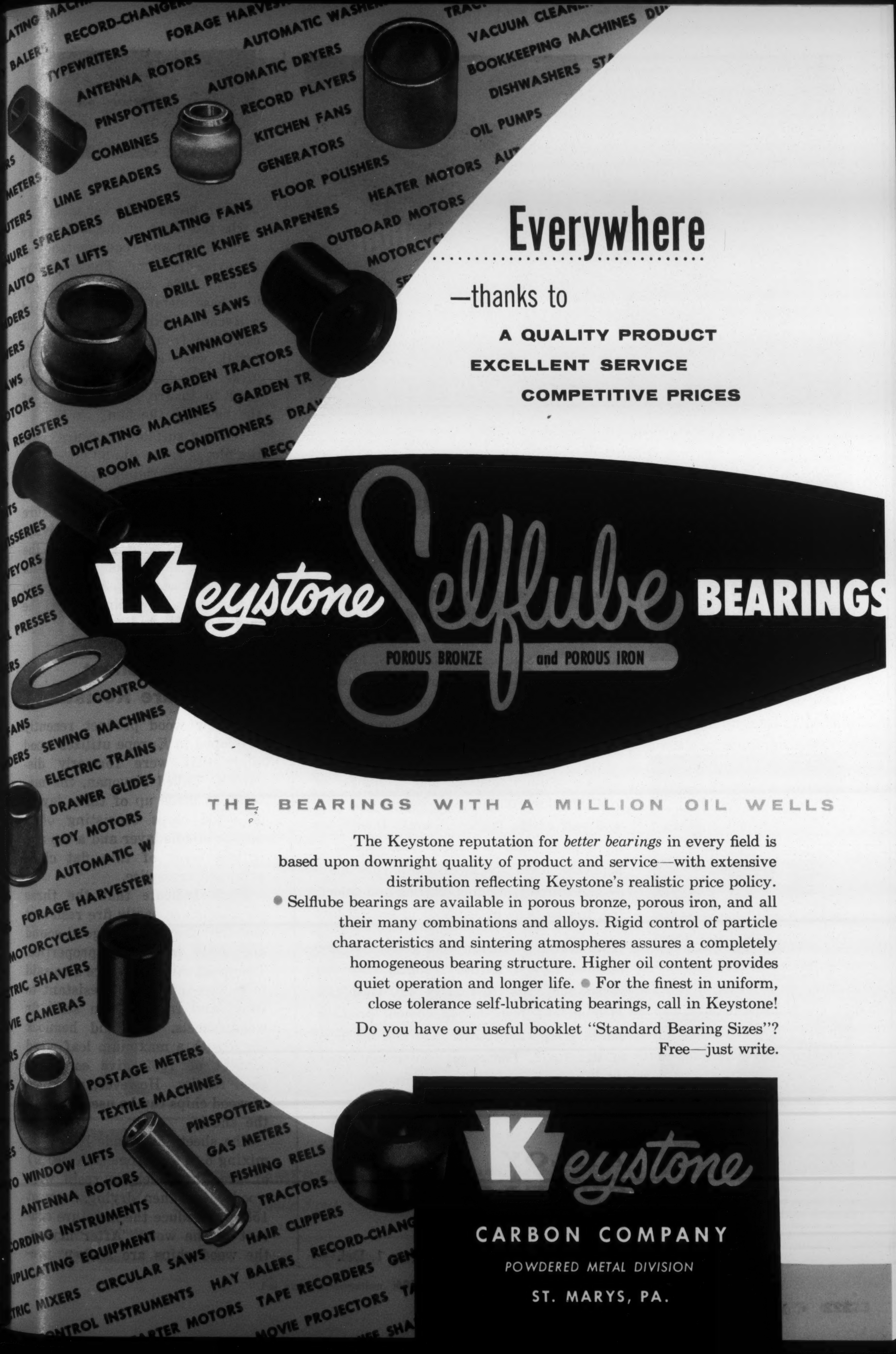
Until now it has been difficult to determine the location and size of pores and other flaws in industrially produced electroplated coatings. Recently, however, the National Bureau of Standards, in cooperation with the American Electroplaters' Society, has developed a nondestructive method for determining both the size and position of pores by exposing an electroplated specimen to radiation.

First step in the procedure, developed by F. Ogburn of the Bureau staff and Margaret Kilkert, AES research fellow at the Bureau, consists of placing a flat sheet of plated metal a few thousandths of an inch thick on a photographic film with the plated coating against the film emulsion. Thickness of the base metal is limited to a few thousandths of



Method *for investigating porosity of electroplated coatings. The coating is placed against the emulsion of the film (bottom) and the base metal side (top) is exposed to x-rays or radiation from a radioactive material.*

For more information, Circle No. 610 ➤


RECORD-CHANGERS
FORAGE HARVESTERS
AUTOMATIC WASHERS
BALERS
TYPEWRITERS
ANTENNA ROTORS
AUTOMATIC DRYERS
PINSPOTTERS
RECORD PLAYERS
COMBINES
KITCHEN FANS
GENERATORS
METERS
LIME SPREADERS
BLENDERS
FLOOR POLISHERS
VENTILATING FANS
MANURE SPREADERS
ELECTRIC KNIFE SHARPENERS
AUTO SEAT LIFTS
DRILL PRESSES
CHAIN SAWS
LAWNMOWERS
GARDEN TRACTORS
DICTATING MACHINES
ROOM AIR CONDITIONERS
VACUUM CLEANERS
BOOKKEEPING MACHINES
DISHWASHERS
OIL PUMPS
HEATER MOTORS
OUTBOARD MOTORS
MOTORCYCLES
REGISTERS
ROTISSERIES
CONVEYORS
BOXES
PRESSES
SEWING MACHINES
ELECTRIC TRAINS
DRAWER GLIDES
TOY MOTORS
AUTOMATIC WASHERS
FORAGE HARVESTERS
MOTORCYCLES
ELECTRIC SHAVERS
MOVIE CAMERAS
POSTAGE METERS
TEXTILE MACHINES
PINSPOTTERS
GAS METERS
FISHING REELS
AUTO WINDOW LIFTS
ANTENNA ROTORS
RECORDING INSTRUMENTS
TRACTORS
HAIR CLIPPERS
DUPLICATING EQUIPMENT
CIRCULAR SAWS
HAY BALERS
RECORD-CHANGERS
ELECTRIC MIXERS
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A QUALITY PRODUCT
EXCELLENT SERVICE
COMPETITIVE PRICES

Keystone Selflube BEARINGS

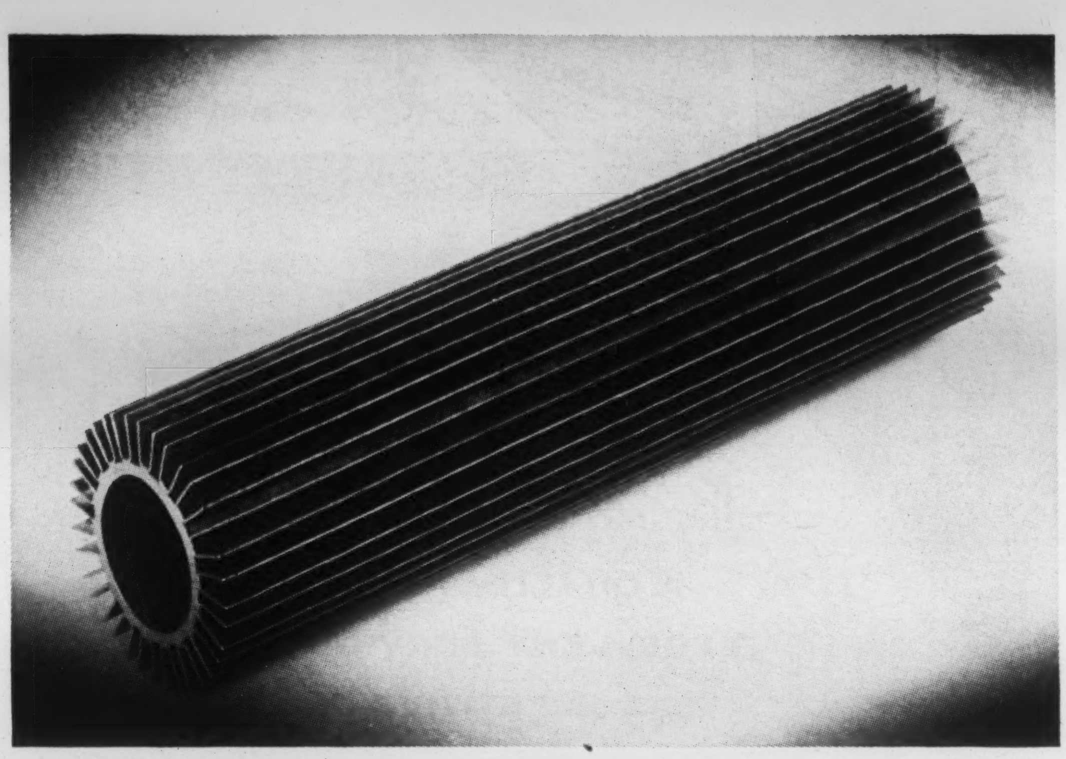
POROUS BRONZE and POROUS IRON

THE BEARINGS WITH A MILLION OIL WELLS

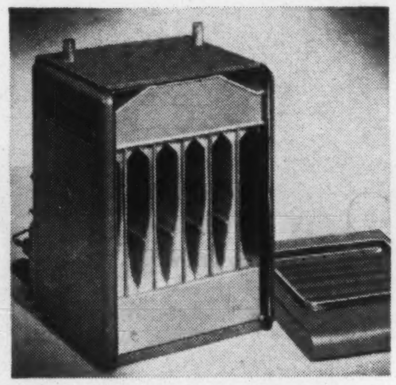
The Keystone reputation for *better bearings* in every field is based upon downright quality of product and service—with extensive distribution reflecting Keystone's realistic price policy. ● Selflube bearings are available in porous bronze, porous iron, and all their many combinations and alloys. Rigid control of particle characteristics and sintering atmospheres assures a completely homogeneous bearing structure. Higher oil content provides quiet operation and longer life. ● For the finest in uniform, close tolerance self-lubricating bearings, call in Keystone!

Do you have our useful booklet "Standard Bearing Sizes"? Free—just write.

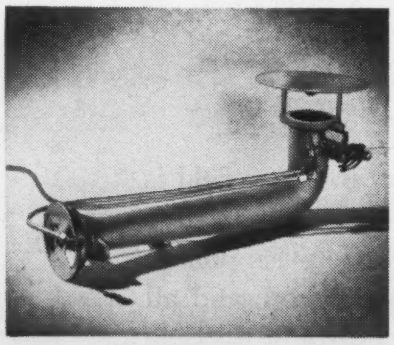
Keystone
CARBON COMPANY
POWDERED METAL DIVISION
ST. MARYS, PA.



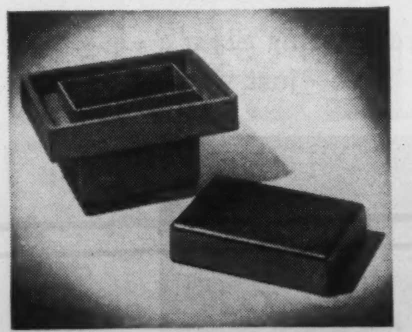
Heat exchanger used in evaporators and condensers will withstand 1600° F indefinitely.



Stainless Alloy Surface protects heat exchanger element in gas-fired unit heater which operates at approximately 1600° F.



Stainless Alloy Surfaced flame spreader replaces Stainless Steel spreader normally used in fuel burner nozzle at a 40% cost saving.



Heat treatment retorts operating up to 2600° F can be protected against heavy oxidation which reduces service life.

Heat Protection

Up to 2600° F.

Steels having a carbon content from 1008 to 1053 can now be given a *Stainless Alloy Surface* providing heat resistance equal to that afforded by Stainless Steels. A new, low-cost process — ASC Metal Diffusion — creates by atom interchange a chromium-rich surface that gives unlimited heat protection at 1600° F. and limited protection up to 2600° F.

Unlike coatings, platings and claddings, an ASC Stainless Alloy Surface becomes an integral part of the processed work. It will not chip, peel, craze or crack. The Process is applicable to all iron, steel, and ferrous alloys — and forming, welding, brazing and soldering, can be done by methods in general use.

ASC Metal Diffusion also gives low and medium carbon ferrous products *corrosion* resistance equal to that of 430 stainless. Medium and high carbon content products can be given *wear* resistance surface hardness of RC 70-72. For more information about this revolutionary process write for data, consultation, or product demonstration.

ALLOY
SURFACES
COMPANY
103 South Justison St., Wilmington 1, Del.

For more information, turn to Reader Service Card, Circle No. 406

an inch because thicker metal absorbs too much of the low energy x-ray beam and requires too long an exposure time. The assembly is held in a cardboard cassette. The base metal side of the plated material is exposed to x-rays or radiation from a radioactive material, such as radioactive iron, nickel or cobalt. Soft x-rays are used to insure good contrast of the flaws on the film.

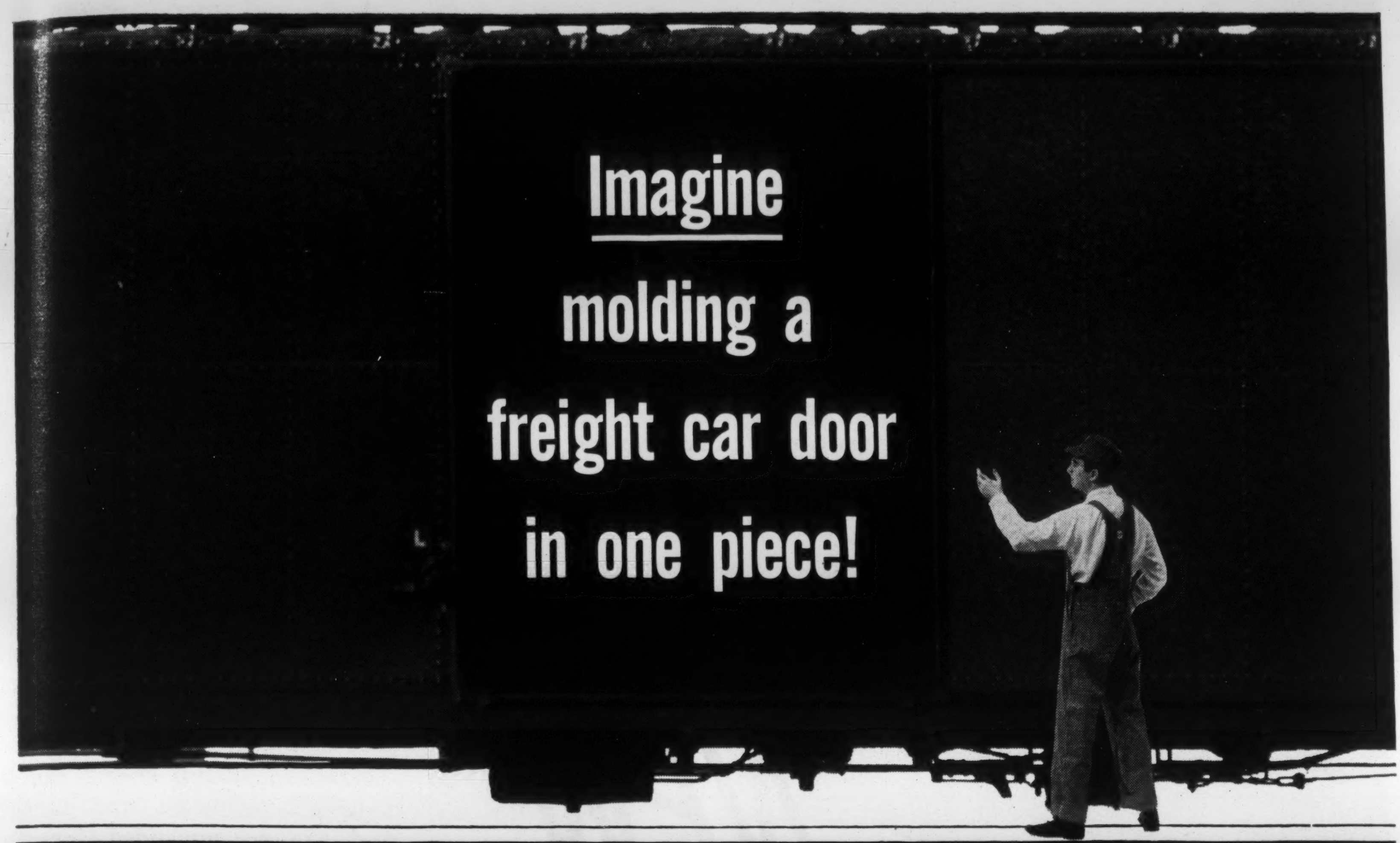
After a suitable exposure time, the film is removed and developed. Satisfactory radiographs result from 3 or 4-min exposure to an x-ray machine or 24-hr exposure to 1 millimicron of radioactivity. Wherever a pore exists in the coating a black spot appears on the developed film. A fine grain industrial x-ray film gives the most readable radiograph.

Wood Chip Sheet Is Moisture Resistant

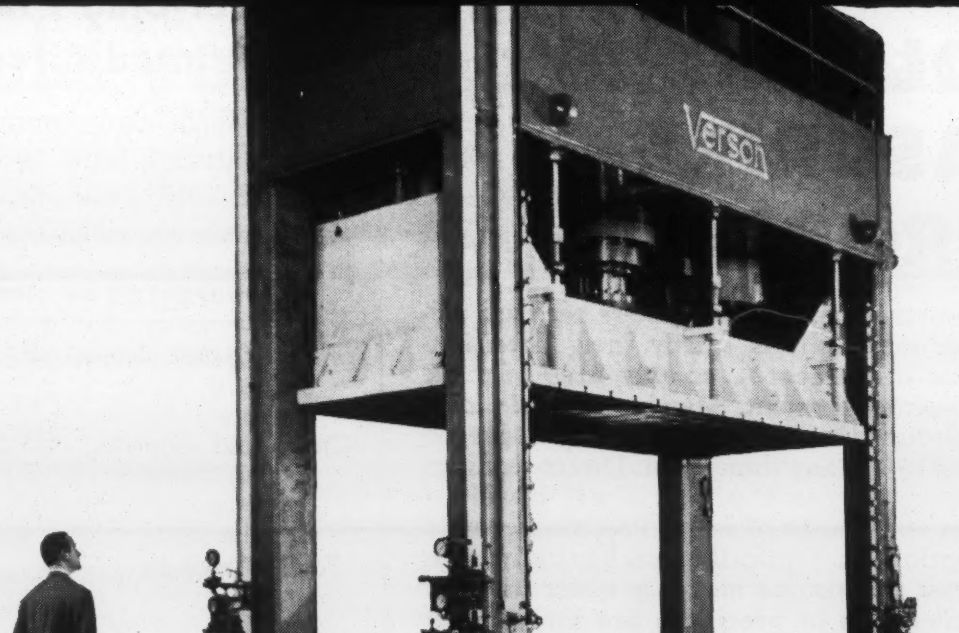
A new wood product recently developed in Europe utilizes wood chips that were formerly discarded. Called Novopan, the material is made up of three layers of wood chips consisting of a porous middle layer and a top and bottom layer of thin flat chips arranged crosswise.

Tests indicate that the three ply sheets are partly fire resistant and that they possess good sound and heat insulating properties. The wood chip sheets are also said to be one-third more resistant to fungi and insects than solid fir wood sheets. Fir and hemlock chips with a maximum leaf wood content of 10% give especially good results. However, all kinds of wood chips can be used to make the sheets.

The sheets are made by slowly mixing 5 to 8% (sometimes 10%) of urea-formaldehyde resin with wood chips, then drying them at 158 F to reduce the moisture content of the wood. After drying, the wood chips are shaken, pre-



THIS GIANT PRESS CAN DO IT!



Built to cut fabrication costs by molding big jobs in one operation, this 1,000-ton press is ready to handle *your* problem jobs—right now.

Boat hulls, door frames, wall panels, hatch covers, desks, bookcases, automobile fiberglass body sections or any part up to 8′ x 15′—in fact, just about any reinforced plastic product can be handled with ease by this unique press, the largest of its kind in the world.

If you are interested in obtaining the service of this press for your product, we'll be very glad to furnish you with detailed production information, complete time and tonnage schedules. Write or call.

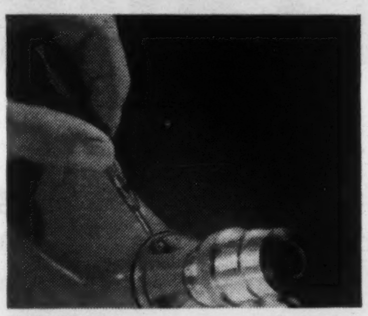
PLASTICS DIVISION
GENERAL AMERICAN
TRADE MARK

GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South La Salle Street • Chicago 90, Illinois

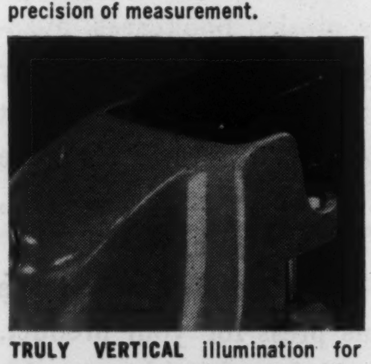
Facilities unmatched anywhere: injection, compression, extruding and vacuum forming, reinforced plastics, painting and assembling

For more information, turn to Reader Service Card, Circle No. 560

Measures tiniest parts, irregular shapes . . . faster, easier, at a budget price



EXCLUSIVE! Fast, easy adjustment aligns crosshairs of eyepiece with x-y motion of stage for absolute precision of measurement.



TRULY VERTICAL illumination for study of deep cavities. Built-in Illuminator provides ample, comfortable light for full-working-day use.

PROTRACTOR EYEPIECE (optional) is quickly, easily interchangeable with standard eyepiece; speeds accurate measurement of angles.

Bausch & Lomb TOOLMAKERS' MEASURING MICROSCOPE

All the features that most toolmakers need are efficiently combined in this sturdy, new precision-measurement instrument . . . at only $1200 for the complete basic equipment. Massive controls, conveniently grouped, assure steady, sharp focus on parts up to 2½" in any dimension. Direct readings to 0.0001"; angular, to 1' of arc. 2" x 1" travel accommodates wide range of work. Precision-ground centers (optional). Optically, mechanically, this new, low-cost microscope makes it easier to work to closer tolerances of precision. See for yourself in a free demonstration.

BAUSCH & LOMB OPTICAL CO.
79316 St. Paul Street, Rochester 2, N. Y.

☐ Send me informative new B&L Toolmakers' Microscope Catalog D-282

☐ I would like an obligation-free demonstration of the new B&L Toolmakers' Microscope

Name, Title..........

Company..........

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City.......... Zone....... State..........

For more information, turn to Reader Service Card, Circle No. 536

pressed at room temperature and hardened in a multilayer hydraulic press at 285 to 300 F under a pressure of 14,000 to 35,000 psi.

A ⅞-in. sheet made by this technique had a bending strength of 220,000 psi and a modulus of elasticity of 42 x 10^6 psi. Moisture content increased only 7% after storage in an atmosphere of 95% R. H. for 152 days. Shrinkage after drying was 2.8% in both length and width; solid fir and hemlock sheets shrank 36% in length and 78% in width.

The wood chip sheets can be painted, varnished and tanned, and are recommended for wall surfaces, furniture and building panels. (Condensed from *European Technical Digests*, Dec '56.)

Copper-Clad Plastic for Printed Circuits

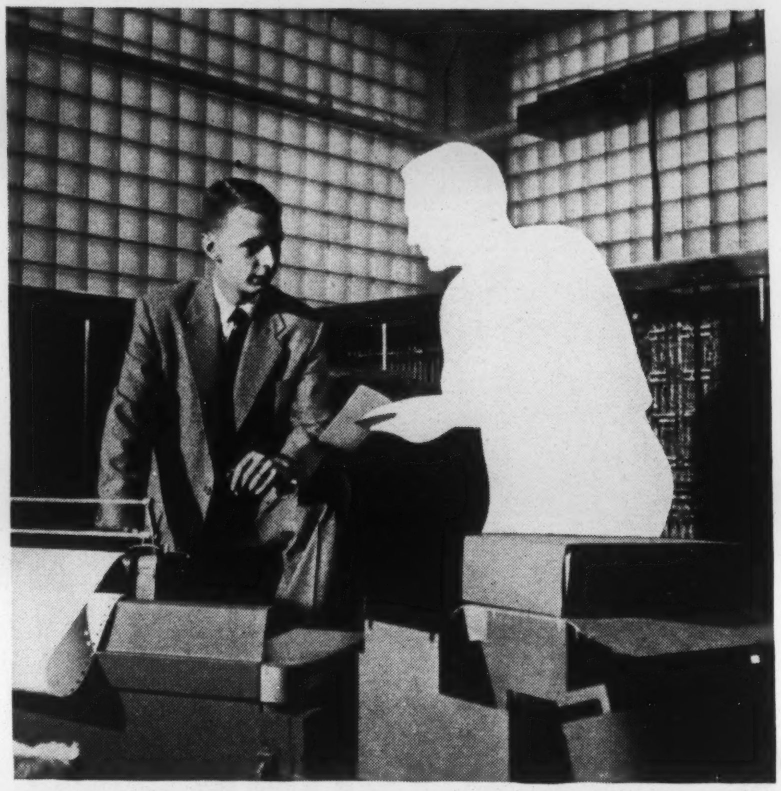
A copper-clad laminated plastics material, said to be an improved XXP grade laminate that also meets specification MIL 3115

PROPERTIES OF CIRPRINT

Flexural Strength (flatwise), psi	
Lengthwise	18,000
Crosswise	14,000
Izod Impact (edgewise, cond E -48/50), ft-lb/in.	
Lengthwise	0.50
Crosswise	0.45
Tensile Strength, psi	
Lengthwise	15,000
Crosswise	10,000
Compressive Strength (flatwise), psi	25,000
Water Absorption (24 hr immersion), % (power)	0.80
Dissipation (power) Factor	
As Received	0.035
24 Hr Immersion	0.040
Dielectric Constant	
As Received	4.70
24 Hr Immersion	4.90
Dielectric Strength (par. to lam), kv	
As Received	80
48 Hr Immersion	60
Dielectric Strength (perp to lam), v/mil	
Short Time	700
Step-by-Step	500
Insulation Resistance (cond C-99/35/90), megohms	50,000

IBM GROWTH promoted these men

Research Engineer: Before his recent promotion, this man was a member of a small research team comprising three E.E.'s and a technician. His specific project entailed the creation of a transistorized electronic converter combining both digital and analog circuitry. "Research is really on the move at IBM," he says. "Personnel has increased ten-fold since 1950 and we expect to maintain this pace for some time."



Manufacturing Engineer: Also promoted recently, this man worked in one of IBM's many manufacturing plants. He was responsible for the analysis, design and procurement of equipment and facilities to produce the giant IBM electronic computers. "In a field as new as electronic computers," he'll tell you, "*unique* manufacturing equipment is often imperative. Creating this new equipment is a real challenge to an engineer's ingenuity."

Could you handle their responsibilities?

Jobs like these continually open up at IBM—due to rapid expansion. If you are an engineer or scientist—or have equivalent experience—you may be qualified for such a position. Innumerable opportunities exist in:

- Computer systems planning
- Computer systems testing
- Electronic circuit design and packaging
- Electrostatic phenomena
- Manufacturing process control
- Numerical analysis and programming
- Photo and magnetic device memory
- Real time systems engineering
- Semi-conductor research, development, and manufacturing
- Test equipment design

The electronic computer field offers one of the best ground-floor career opportunities today. Economic experts rank it with automation and nucleonics in growth potential. Sales at IBM, the recognized leader in this fast-growing field, have doubled, on the average, every five years since 1930. Engineering laboratory personnel has quintupled in the past five years. IBM's excellent salary and employee benefit program is instrumental in achieving an employee turnover rate far below the national average.

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City____________________Zone________
State____________________
Experience and/or educational background____________________

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. . . check with Milford Engineers!

Riveting raises *special* problems and requires *special* skills. You must have the right type and size rivet for each application, or the results can be costly . . . in production and in profits. When you're faced with a riveting problem, let Milford engineers lend a hand before designs are fixed!

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. . . to take full advantage of automatic assembly
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B, has been introduced by Formica Corp., 4408 Spring Grove Ave., Cincinnati 32, Ohio.

Designated Cirprint, the paper-base material is said to have good insulation resistance, low moisture absorption and good cold punching qualities. The material is translucent; its translucency is said to offer two advantages: 1) it permits a visual check on the register of a circuit printed on both sides, and 2) it permits a visual check for voids, blisters or other impurities that might reduce electrical insulating properties of the sheet.

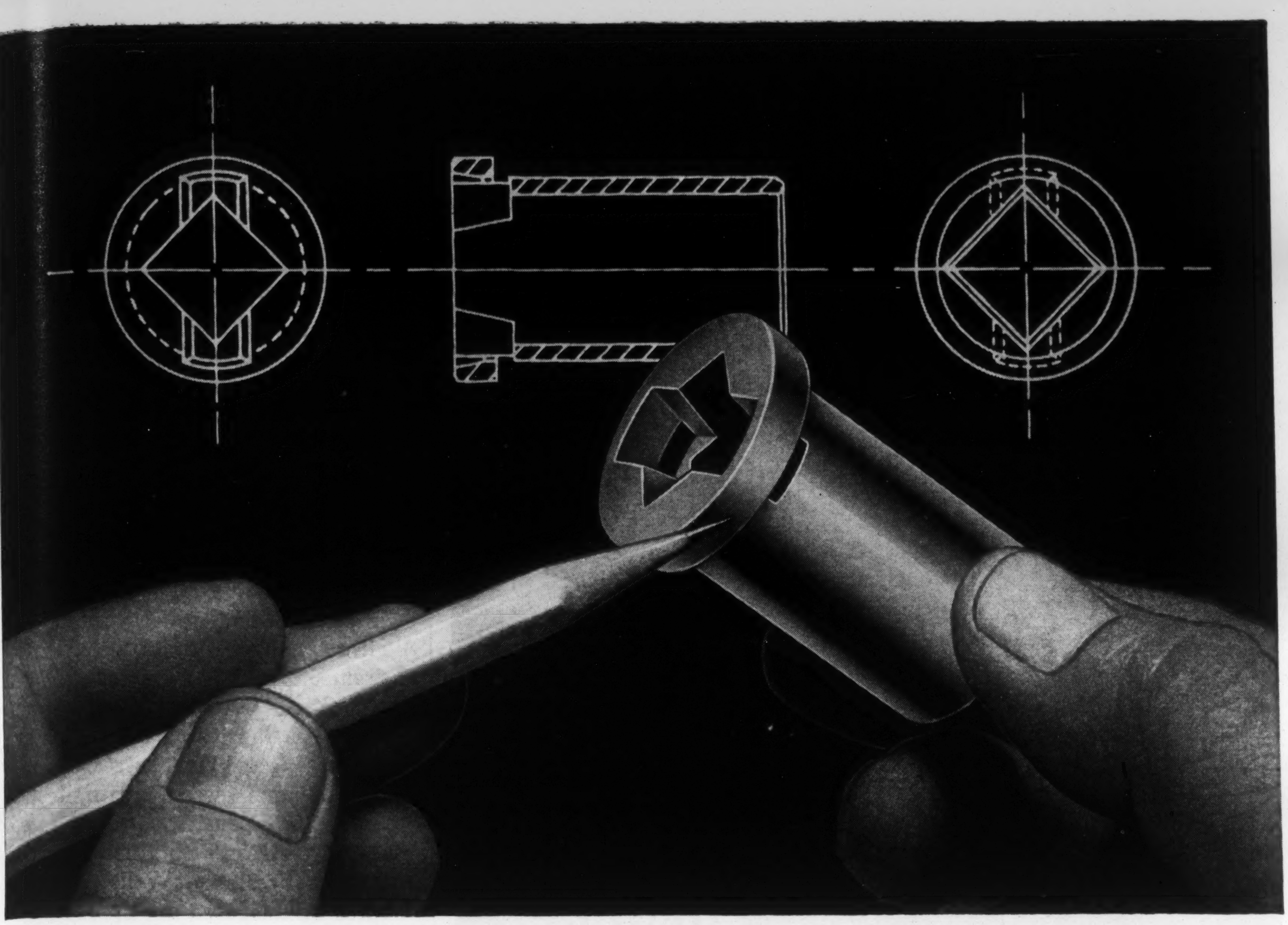
Tank Lining Sheet Needs No Field Curing

A ready-cured, synthetic rubber tank-lining sheet that is said to eliminate the necessity of curing in the field or of moving equipment from its operational location, has been announced by E. I. du Pont de Nemours & Co., Inc., Fabrics Div., Wilmington 98, Del. Called Fairprene T-5594, the synthetic rubber lining material is offered as part of a packaged consisting of primers, adhesives and putties.

The material is stable in storage and requires no refrigeration. Its stretch is said to approach that of natural rubber lining materials, and applied cost per square foot is said to be appreciably lower than that of natural rubber and other materials now in use. It is available as a two ply, 50-in. wide sheet ⅛ in. thick.

Magnesium Properties Vary with Heating Rate

Aerodynamic heating of aircraft and missiles has led to considerable research on the strength of materials at elevated temperatures. Recent investigations have shown that materials exhibit



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Can't be done? Parker did it . . . sharp internal corners, lateral holes, chamfers, flanged end and all . . . by fast, low-cost powdered metal pressing and sintering. No subsequent machining . . . no scrap-metal loss. Just think of the savings compared with conventional machining methods.

In addition to these inherent cost savings, Parker-engineered Powdered Metal Parts offer a wide choice of tensiles, ductility, density, impact resistance and other physicals. Tooling-up is done quickly and at relatively low cost.

It will pay you to check on the economies and design possibilities of Parker-engineered Powdered Metal Parts. Just call the nearest sales engineer listed here or write the factory direct.

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high pressure
ALUMINUM and ZINC
die castings
POWDERED METAL PARTS

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This Hevi Duty pit furnace is used to "bright" harden parts for Cutler-Hammer temperature controls.

eliminate
a cleaning operation
by "bright" hardening in a
HEVI DUTY PIT TYPE
CONVECTION
FURNACE

Beryllium copper parts come out of this Hevi Duty Pit Furnace clean and bright — ready for the production line. Cutler-Hammer, Inc. has eliminated a costly cleaning operation by "bright" hardening in this Hevi Duty Pit Furnace. Prepared Atmospheres are supplied by a Hevi Duty CU-200 Gas Preparation Unit. Learn more about "bright" hardening and annealing in Hevi Duty pit furnaces. Write for Bulletin HD-451 — Today.

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greater tensile strength when heated at rapid rates than under conventional constant temperature test conditions. The latest of these investigations, by Ivo M. Kurg, of the National Advisory Committee for Aeronautics, was conducted on AZ31A-O magnesium alloy sheet. Kurg's work shows that:

1. At all stress levels tensile yield and rupture temperatures increase linearly with the logarithm of the heating rate for rates from 0.2 to 100 F per sec.

2. Yield stresses obtained from rapid heating tests can be greater or less than yield stresses obtained from stress-strain tests, depending upon temperature rate. Rupture stresses obtained in rapid heating tests at all heating rates investigated are appreciably greater than the ultimate tensile stresses from stress-strain tests.

3. Yield and rupture temperatures, or the corresponding stresses, can be predicted for any heating rate by master curves and heating rate parameters.

A new material, HK 31XA-H24 magnesium alloy sheet, was also tested under the same conditions. Results indicate that the experimental sheet material has elevated temperature properties under both constant temperature and rapid heating conditions that are superior to those of AZ31A-O alloy. However, because the material is still in the developmental stage, these results may not be typical.

Two Epoxy Resins for Potting, Casting

Two epoxy resins for casting, potting, laminating, encapsulating and other purposes have recently been introduced by Marblette Corp., 37-31 30th St., Long Island City 1, N. Y.

One resin, designated Maraset Rubber-Like Resin No. 636, is a flexible compound having an elon-

For more information, Circle No. 621 ➤

gation of 200% and a tensile strength of 2500 to 3500 psi. It can be used to produce low-cost castings in unlimited thicknesses and a wide range of hardnesses. Ideal for potting, sealing and encapsulating electronic components, it can also be used as a replacement for rubber or plastisols in gaskets and other applications.

The other resin combines the properties of rigid and resilient epoxies in a single resin system. Designated Maraset Casting Resin No. 650, it is described as a low-irritant formulation with an elongation of 3 to 5% and an unnotched Izod impact strength of 7 ft-lb per in. The rigid epoxy compound has a Rockwell M hardness of 100 and an ultimate compressive strength of 40,000 psi.

Wood Flake Board

A particle board for furniture and other nonstructural applications has been introduced by Formica Corp., 4819 Spring Grove Ave., Cincinnati 32, Ohio. The wood particle board, composed of wood flakes and resins, is made under pressure and heat. Called Flakeboard, the material is not easily splintered or broken, and it can be sawed and planed without difficulty. It has a modulus of 3500 psi and a direct screw holding power of 350 lb. It will be available in sheet sizes up to 6 x 12 ft, ranging in thickness from ¼ to 1¼ in.

Stainless Pipe to Take Steam at 5000 Psi

For the first time in turbine history a stainless steel pipe will carry steam at 1200 F at a working pressure of 5000 psi. The pipe, 10 in. in dia with a 3½-in. wall and 9-ft length, will be used in Philadelphia Electric's Eddystone, Pa., power plant.

Modified type 316 stainless steel

Centrifugally Cast Pipe is STRONG Pipe.........it's alloyed to resist corrosion and high temperature

Planning to install high pressure lines in your plant? Will they carry hot corrosive liquids or gases?

You will find SAFETY in DURASPUN Centrifugally Cast Pipe. It's very strong, with strength approaching that of forged steel. It can be alloyed to give you maximum resistance to the heat and corrosion to be encountered.

DURASPUN Pipe comes in a wide range, as follows:

Outside Diameter	Minimum Wall	Length
2½" to 3"	1/4"	88" maximum
3" to 6" Inclusive	5/16"	110" maximum
Over 6" to 12" Inclusive	3/8"	168" maximum, 24" minimum
Over 12" to 14" Inclusive	7/16"	168" maximum, 24" minimum
Over 14" to 20" Inclusive	1/2"	180" maximum, 48" minimum
Over 20" to 24" Inclusive	1/2"	88" maximum
Over 24" to 32" Inclusive	5/8"	80" maximum

This is standard piping. Special cylindrical shapes in comparable high alloy steel can be cast centrifugally . . . retorts, furnaces, fractionaters and other such equipment come in this class.

Write us about your requirements. Our metallurgists backed by thirty-five years of experience will be glad to help select the best combination of alloying elements to take care of your operating conditions.

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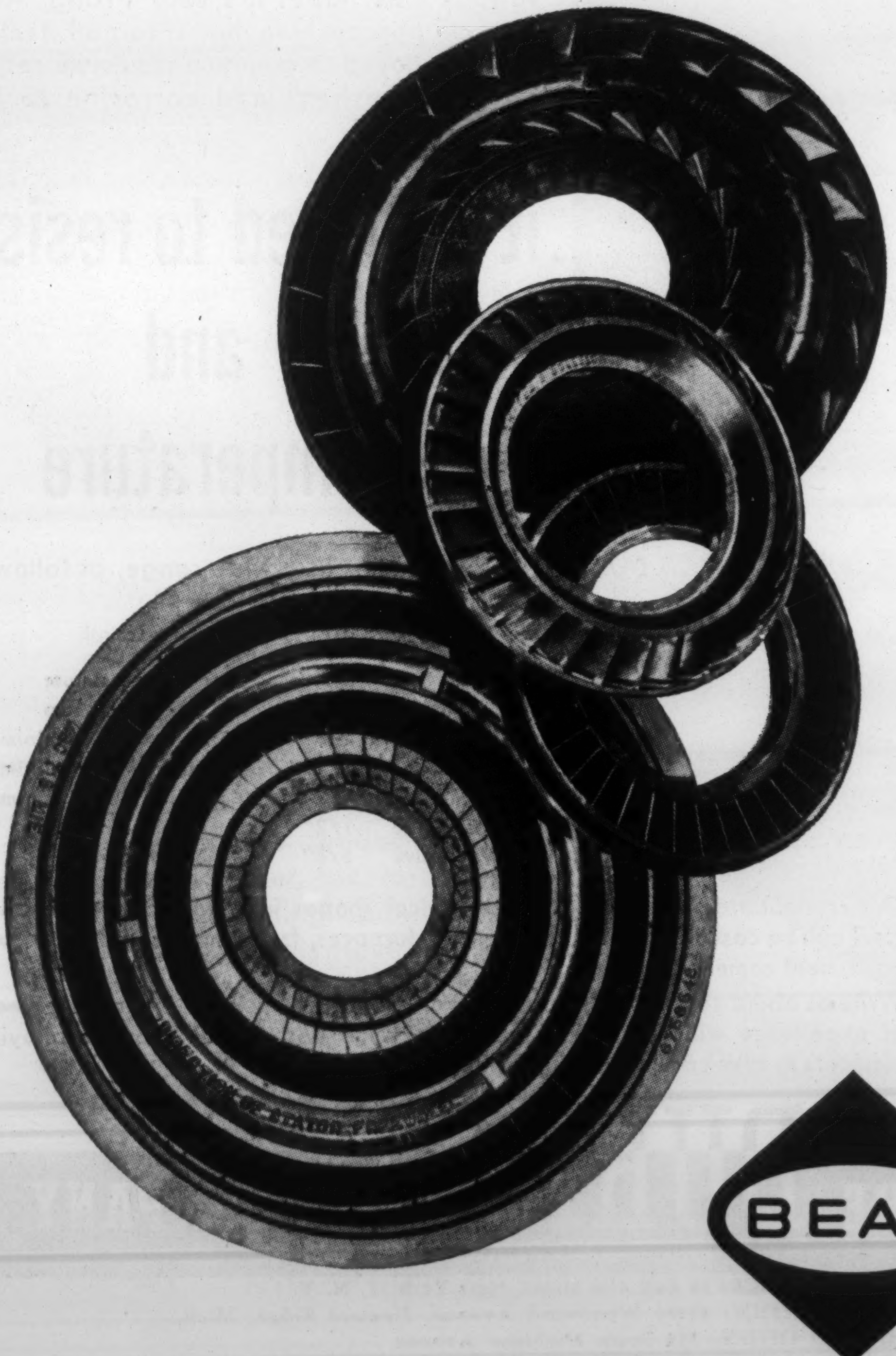
In this 45 pound set of torque converter elements all critical dimensions are held to ± .015", with a similar order of excellence in metallurgical properties and surface smoothness. The user reports measurably superior performance in the assembled unit. If you make torque converters, ask us to quote on your next requirement.

Our unique production foundry techniques routinely solve requirements for problem aluminum parts. We are at home in the demanding areas of fluid flow, microwave, and aircraft castings of any size. Send for illustrated technical booklet now.

Morris Bean & Company
Yellow Springs 1, Ohio

cast torque converters



BEAN

For more information, turn to Reader Service Card, Circle No. 516

ingots weighing five tons were bloomed into billets by Sharon Steel Corp. and forged by Pennsylvania Forge Co. The final product will be fabricated and installed by M. W. Kellogg Co.

Evaluating Paper As a Core Material

Considerable savings in core materials for sandwich construction may be afforded by the use of resin-impregnated paper. Over the years the search for a suitable core material for use in sandwich panel construction has included an economic, chemical and mechanical evaluation of numerous core materials, including balsa wood and rubber and plastics foams. From the standpoint of economics and availability, resin-impregnated paper has played a large role in the development of the sandwich panel.

Recently the Forest Products Laboratory undertook a study to see whether the cost of resin-impregnated paper honeycomb cores could be further reduced. This was done by evaluating the effects of 1) lowering the resin content, 2) reducing the weight of the paper, and 3) using less costly adhesives on the strength, decay resistance and other properties of the sandwich panel. The study was done in cooperation with the Housing and Home Finance Agency and the University of Wisconsin, and the investigators included R. J. Seidl, E. W. Kuenzi, D. J. Fahey and C. S. Moses. Details of this study may be found in Report No. R 1796 issued by the Forest Service Div., U.S. Dept. of Agriculture.

Effect of resins

From the standpoint of lowering the resin content, the properties of paper cores containing 5, 10 and 15% of phenolic resin were compared with those of unimpregnated paper. The base

TAYLOR
Laminated Plastics
Vulcanized Fibre

Shop Talk

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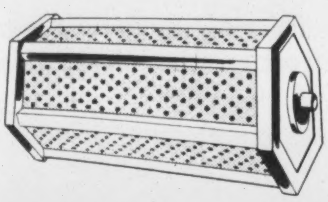
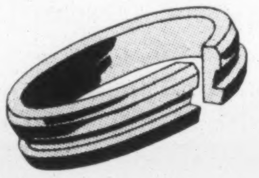
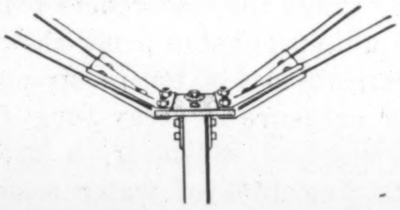
Tips for designers



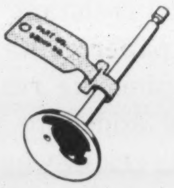
"Metal-plating barrels" of Taylor Grade C-5 melamine withstand corrosion and erosion successfully in alkaline solutions. Downtime and maintenance costs are substantially reduced.



Self-retaining grommets cut from Taylor phenolic tubing shield cables and wires passing through bulkheads . . . offer good electrical insulating properties.



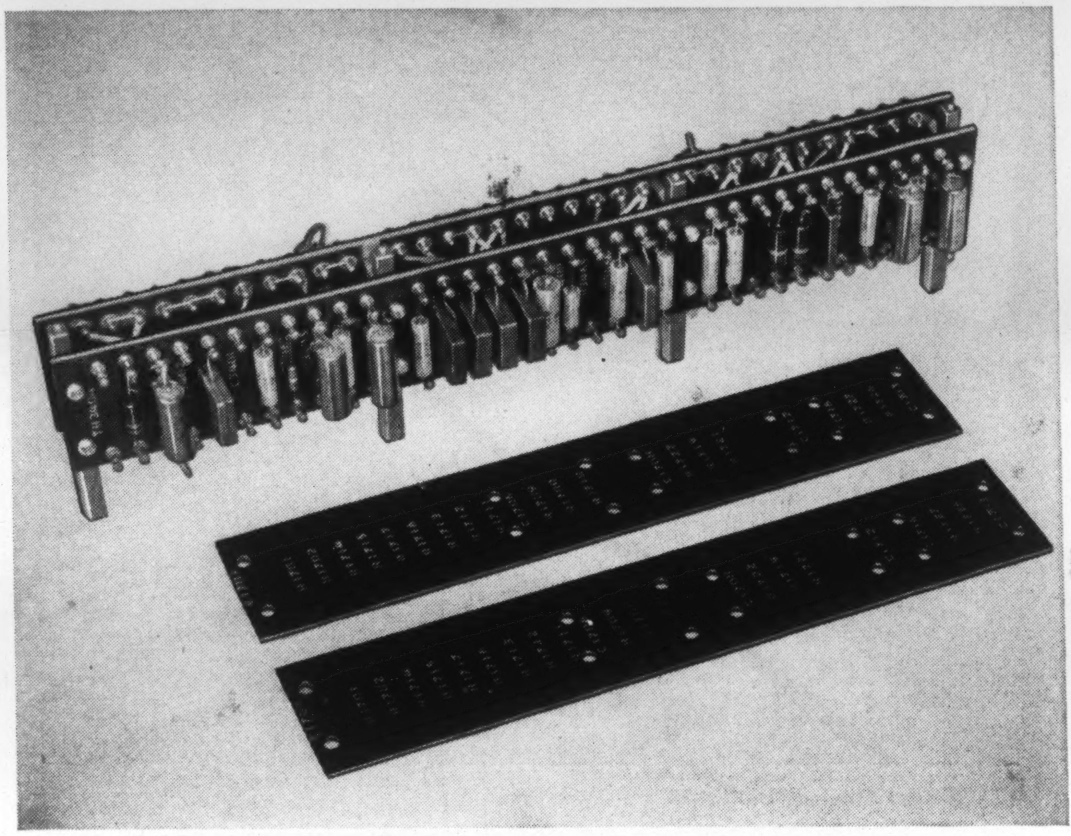
Insulation support of TV antenna rods is made of Taylor laminated phenolic which assures dependable, moisture-resistant insulation . . . is unaffected by weather.



Identification tag, easily fabricated from Taylor super-white vulcanized fibre, is non-abrasive and non-corrosive, can be printed and has safe, non-cutting edges.

NEW TAYLOR COPPER-CLAD LAMINATES

Taylor GEC (glass epoxy) Copper-Clad and Taylor XXXP-242 cold punching (paper-phenolic) Copper-Clad. Taylor uses high purity rolled copper on base materials with outstanding electrical properties.



Six resistor board assemblies on the new Martin Matador guided missile are of Taylor Grade GEC (glass epoxy) laminate, chosen for this tough application because of its stable electrical properties and humidity resistance.

Taylor Glass Epoxy Laminate meets critical insulation needs

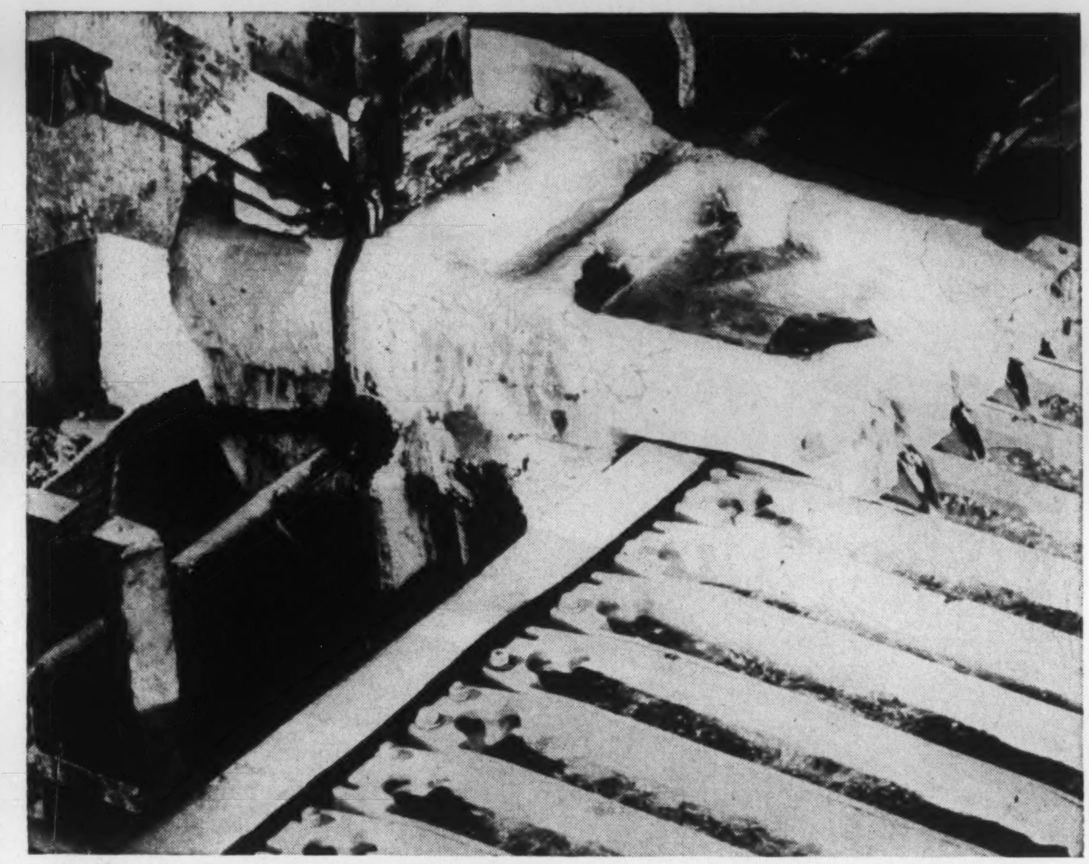
Taylor GEC (glass epoxy) meets the Matador's exacting electrical insulation requirements. These requirements consist of . . . high strength to withstand the G's . . . low moisture absorption to withstand the varying humidity and temperature . . . electrical and mechanical stability. Your requirements, which are no doubt different, may be equally exacting. Taylor's wide range of laminates include that combination of electrical, mechanical and chemical properties that you require.

Designed for ease of fabrication . . . Taylor laminates are the result of resin formulations and production techniques developed to make fabrication of completed parts easier and less costly. They are especially suited to punching, staking, milling, sawing or drilling when accurately sized parts are a must.

When specifications call for stability, specify Taylor laminates. They maintain their original characteristics over long periods of time and under rugged operating conditions.

To help you in your selection of a laminate, Taylor's engineering staff and fabricating facilities are at your service. Contact your nearest Taylor sales engineer for a discussion of your particular requirements.

For more information, turn to Reader Service Card, Circle No. 402



Federated Aluminum Alloys always conform to published Performance Specifications

If you have had reason to doubt the performance capacity of certain aluminum alloys, it will pay you to consult Federated before you re-design or substitute another metal.

Often the performance requirements of a part indicate that a certain aluminum alloy will do the job; yet in operation, the part fails. Costly re-design or a more expensive metal are usually relied upon to rectify the trouble.

All aluminum alloys should provide the characteristics set for them in published specifications. At Federated's three aluminum plants, rigid quality control insures that production ingot adheres exactly to specified content. Impurities are held at or below the minimum allowable percentage.

Every heat of every Federated aluminum alloy is tested exhaustively. Refining, alloying and testing techniques are under the supervision of ASARCO's Central Research Laboratory, where scientists can control metal impurities to parts per million, if required.

A Federated field man will be around to see you soon. Spend some time with him. It will benefit you.

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material of the cores consisted of Kraft paper of 30-, 50- and 65-lb weight, and the densities of the cores ranged from 1.6 to 3.0 lb per cu ft.

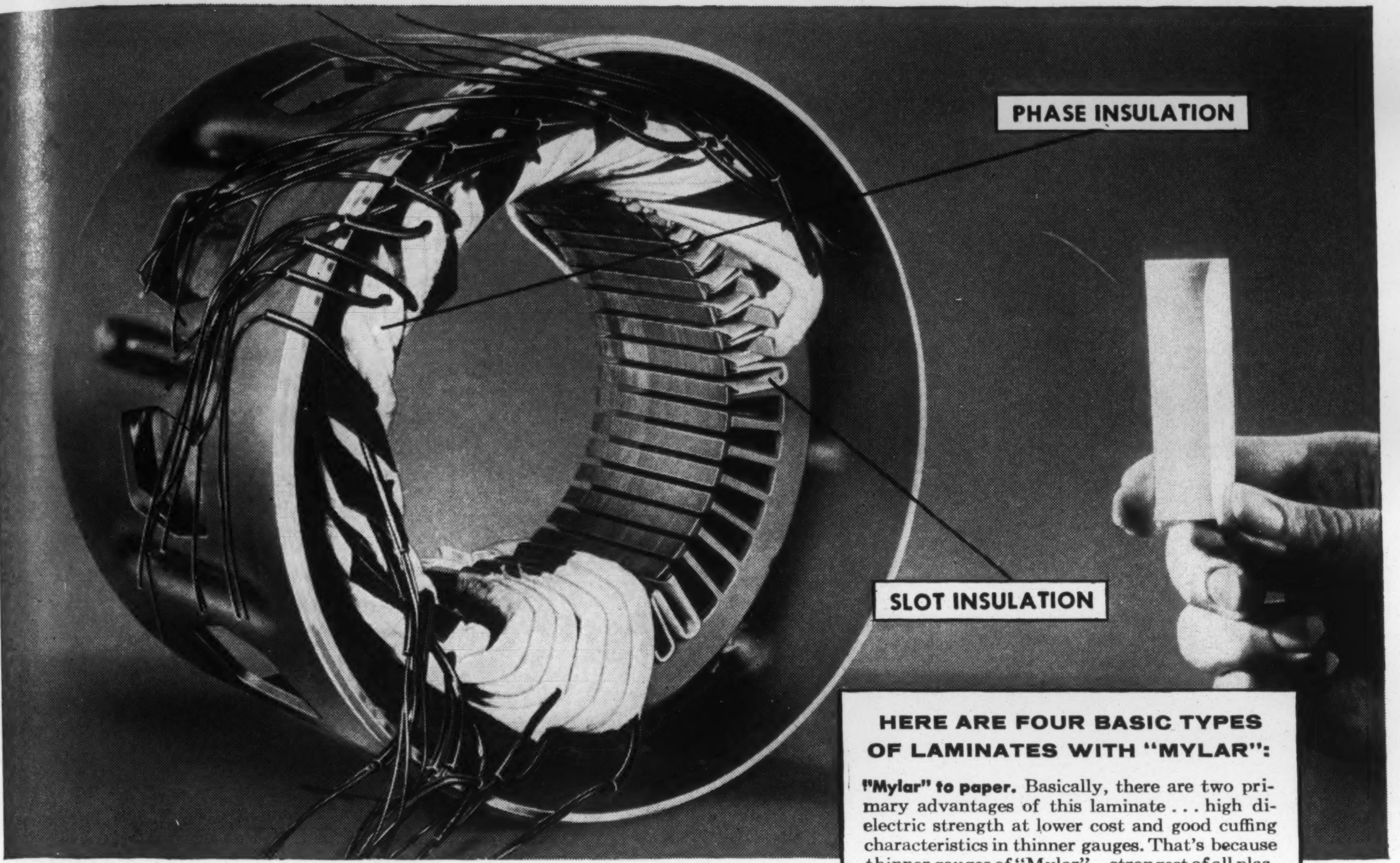
The effect of phenolic resin impregnation on the physical properties of the paper was reflected chiefly in greatly increased tensile strength of the paper, particularly in the wet condition. The greatest increase in wet tensile strength of the paper was obtained from the first 5% of resin. Wet tensile strength in the machine direction increased from 3 to 30 lb per in. of width with a 5% resin addition, and to 40 lb per in. with a 15% resin addition. Dry tensile strength of the paper increased from 35 to 42 lb per in. of width with a 5% resin addition and 50 lb per in, with 15% resin.

With respect to the effects of decay fungi, the researchers found that unimpregnated paper showed a complete loss of tensile strength after exposure to decay fungi for two months. However, a paper containing 15% of water soluble phenolic resin had practically no loss in strength under similar exposure. Paper impregnated with water soluble phenolic resin was much more resistant to decay fungi than paper containing alcohol soluble phenolic resin. Pentachlorophenol added to paper containing 5% resin was found to suppress the action of the fungi.

Effect of adhesives

To explore the effect of the quality of the bond between sheets of paper on the properties of a sandwich construction, a series of tests was made to compare phenolic, urea and sodium silicate adhesives. Results gathered from a number of tests indicated that maximum strength, regardless of adhesive, was obtained by placing the web of the corrugated paper parallel, not perpendicular, to the span of the shearing specimen. Other test results indicated that the tensile and shearing strengths

DU PONT MYLAR®



HERE ARE FOUR BASIC TYPES OF LAMINATES WITH "MYLAR":

"Mylar" to paper. Basically, there are two primary advantages of this laminate . . . high dielectric strength at lower cost and good cuffing characteristics in thinner gauges. That's because thinner gauges of "Mylar"—strongest of all plastic films—can be used.

"Mylar" to glass cloth. Because "Mylar" remains dimensionally stable from −60° to 150° C., "Mylar" laminated to glass cloth offers superior insulation at both high and low temperatures. In addition to high flexibility, this laminate has good forming characteristics in thinner gauges.

"Mylar" to asbestos. Excellent for motors and generators operating in the Class "B" temperature range. Coated asbestos laminated to this tough polyester film produces a stronger product with increased moisture resistance.

"Mylar" to mica. This laminate offers *maximum* insulation plus flexibility. In short, mica is easier to work with when laminated to "Mylar". Costs are lower too because thinner gauges of mica can be used . . . Du Pont "Mylar" gives the mica "body."

MYLAR—and laminates with MYLAR—offer superior insulation performance

As most of the nation's leading electrical manufacturers have discovered, Du Pont "Mylar"* polyester film and laminates with "Mylar" offer a wide range of superior insulating properties. The superior qualities of this thin, flexible film can be translated into performance benefits when manufacturing a variety of electrical products! Examples include:

MOTORS—Manufacturers have been able to extend motor life by as much as 100%.

TRANSFORMERS—Manufacturers have been able to reduce size, weight and insulation costs.

CABLE—Manufacturers have been able to speed up production while reducing size and weight.

MAGNETIC AMPLIFIERS—Manufacturers have been able to reduce rejects due to moisture penetration.

The common denominator in each instance is "Mylar". . . with its resistance to moisture, chemicals; its high physical and dielectric strength even in thin gauges; and its thermal qualities. If you have a particularly tough insulation problem, write Du Pont today.

- If you like to compare the properties and cost of the insulating materials, send for our new pocket-size Cost and Property Comparator. It operates like a slide rule . . . quickly determines costs of insulating materials on a sq. ft. basis . . . quickly compares the properties of "Mylar" and seven other materials.

Du Pont manufactures the basic material "Mylar"—not finished electrical laminates.

**"Mylar" is Du Pont's registered trademark for its brand of polyester film.*

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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

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MYLAR®
POLYESTER FILM

☐ Please send "Cost and Property Comparator".

☐ Please send me more information on properties, types and applications of "Mylar" available (MB-11).

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Room MM-4, Nemours Bldg., Wilmington 98, Delaware

I am interested in "Mylar" for________________

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Firm________________

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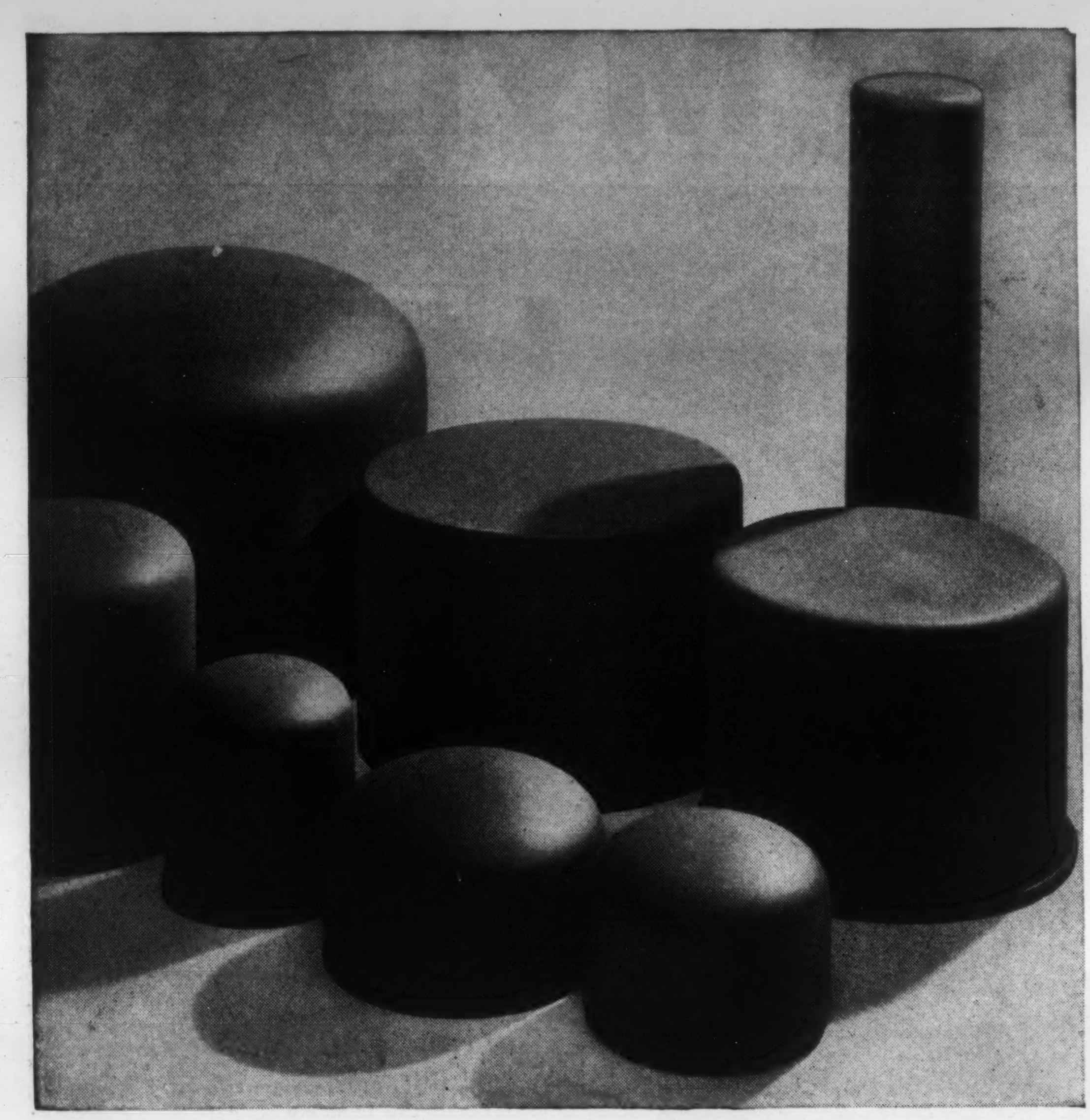
For more information, turn to Reader Service Card, Circle No. 574



Keep pace with the march of design with Hackney deep drawn shells

Your customers want smartly designed products...good looking and durable. Your production engineers demand parts that are readily obtainable...easily and quickly assembled...made to accurate specifications. Management says reduce weight and cut unit costs.

Many product designers have found a single way to solve all these problems. They specify Hackney deep drawn shapes or shells. These lightweight, seamless parts may be cylindrical, spherical, conical or tapered...most any streamlined shape your designs call for. Capacities from one quart to 70 gallons. Flanges, openings, fittings or brackets placed where you need them. Just send us a sketch of what you have in mind. Let us know whether you're thinking of steel, stainless steel, nickel, aluminum, magnesium, copper or alloy. We'll send you the details.

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of core specimens bonded with sodium silicate adhesive were slightly higher when dry and slightly lower when wet than corresponding values obtained from specimens having cores bonded with phenolic adhesives.

It was also found that the strengths of panels having cores constructed without the use of a crest adhesive were slightly lower than those of panels having cores constructed with a crest-to-crest adhesive, a fact indicating that high quality bonding between individual sheets in cores is not essential.

Effect of paper weight

A Kraft paper was used in the test because of its availability in large tonnages at a reasonable price and because it seems to be a stable material. A further economy is possible by using paper made of less expensive fibers. Paper of less than 30-lb weight was not used because it was believed that a lighter paper would present problems of corrugating and handling at high production rates.

As the weight of the paper containing 5% of resin was increased, the shear stress (developed in bending) and the compressive strength of the dry sandwich panels increased considerably. However, there was no significant increase in the physical properties of panels tested in the wet condition.

Increasing the paper's weight from 30 lb to 50 lb increased the dry shear strength from 28 psi to 52 psi for a phenolic resin-bonded core, although the strength of corresponding specimens tested wet remained virtually unchanged. For paper containing 15% resin, the wet shear strength was more than doubled by increasing the weight from 30 lb to 50 lb. The increase in wet compressive strength was not so great. No reason is given for the difference in physical properties of the 5 and 15% resin treated papers tested wet.

(more What's New on p 238)

Wherever you want to protect something

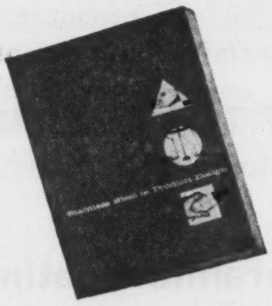
. . . that's a place for A-L Stainless Steel

In a textile plant, like the applications pictured above, Allegheny Ludlum Stainless Steel protects against off-colors in the dyeing and finishing department because it cleans up easily and quickly from batch to batch, leaving no traces of the previous dyes. In yarn twisters and other equipment in the weaving department, A-L Stainless provides the hard, smooth surface and high abrasion-resistance that protects against snagging and binding.

Food, beverage, dairy, drug and chemical plants use A-L Stainless Steel to protect the purity of their products; hospitals, hotels and restaurants use it to protect appearance and sanitary standards; cars, trains and planes use it to protect strength and safety. And they all gain a host of bonus benefits from stainless steel, too: such as far less cleaning and maintenance expense, far longer life in service, and far greater economy in the long run.

No other metal can match stainless steel in these qualities. In addition, A-L Stainless is easy to fabricate and we produce it in every form or shape that you may require.

● Let us help you to profit by it. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*



Write for your copy of "STAINLESS STEEL IN PRODUCT DESIGN"

40 pages of useful engineering and fabricating data, including practical examples showing where, when and how stainless steel improves design, adds benefits, helps sales.

ADDRESS DEPT. MM-88

For Stainless Steel in ALL Forms—call

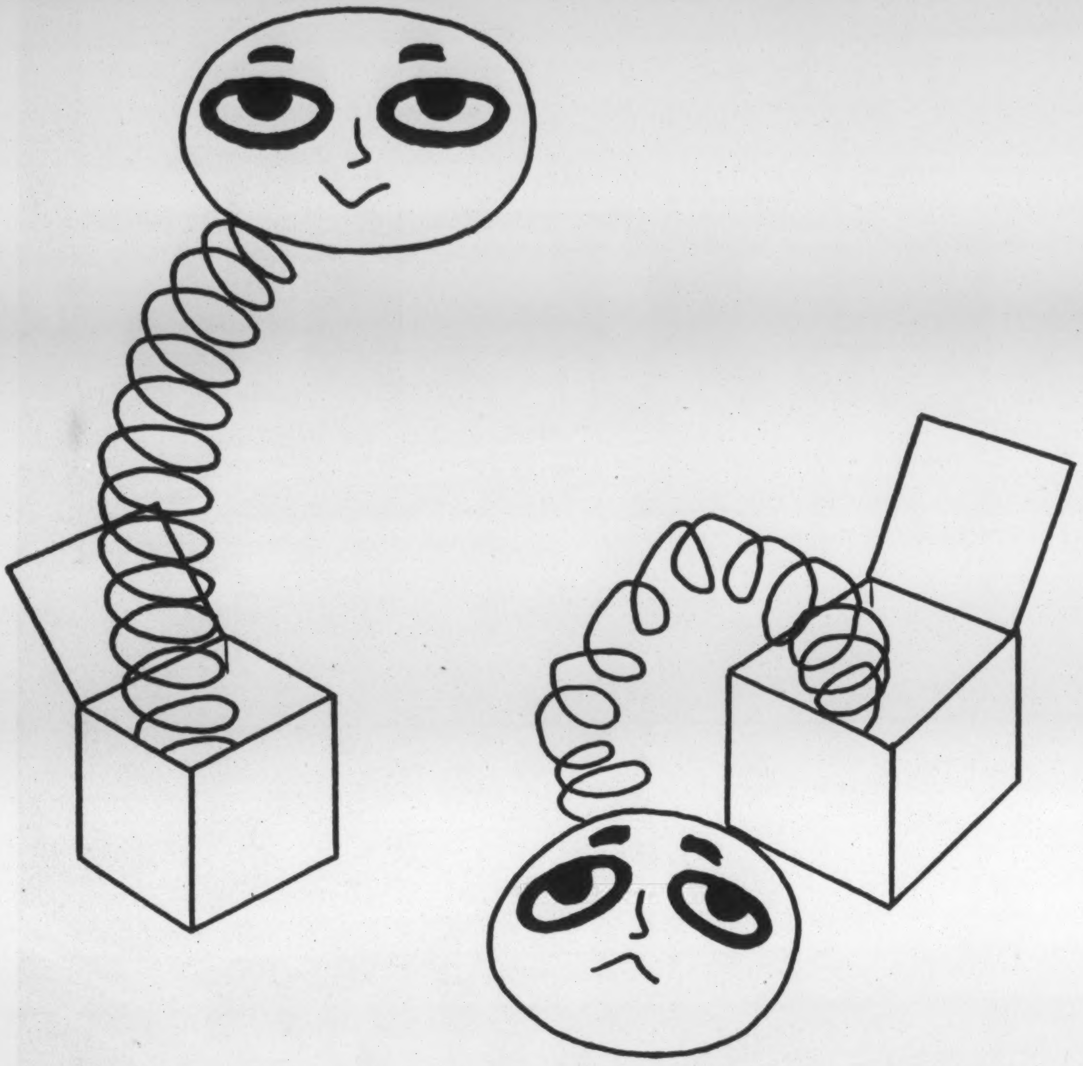
Allegheny Ludlum

A-L STAINLESS STEEL ®

WSW 6092

Warehouse stocks carried by all Ryerson Steel plants

For more information, turn to Reader Service Card, Circle No. 580



Some Springs Have It...Some Don't

The difference in spring performance is most often due to the wire or strip used... and there's more to a spring material than just the "bounce". How about other requirements, such as corrosion resistance, high temperature properties, fatigue resistance and low temperature toughness.

When your springs need any of these properties your best bet is one of our alloy spring materials.

Riverside-Alloy Metal Division can supply you with spring wire and strip in stainless steels, nickel alloys, phosphor bronze and beryllium copper.

Learn more about our spring materials. Write to
Riverside-Alloy Metal Division,
H. K. Porter Company, Inc., Riverside, N. J.

Send today for our free handbooks

DESIGN HANDBOOK
Riverside Alloys

ALLOY METAL WIRE
Prospect Park, Pa.

RIVERSIDE METAL
Riverside, N.J.

PRENTISS WIRE MILLS
Holyoke, Mass.

HKP RIVERSIDE-ALLOY METAL DIVISION
H. K. PORTER COMPANY, INC.

For more information, turn to Reader Service Card, Circle No. 509

What's new IN MATERIALS

Braided Copper Wire in Stretchable Cord

A new electric cord that stretches is composed of a rubber core wound or braided with copper. Fiberglass, rayon, silicone rubber or nylon may be used as insulation.

Called Elasticable and produced by Mutual Electronic Industries Corp., the new cord is designed for use in telephones, switchboards, appliances, and other industrial and military applications.

Pure Titanium Powder Has Good Stability

Development of a pure titanium powder that can be easily formed by powder metallurgy techniques into corrosion resistant parts has been announced by United International Research, Inc., 38-15 30th St., Long Island City 1, N. Y.

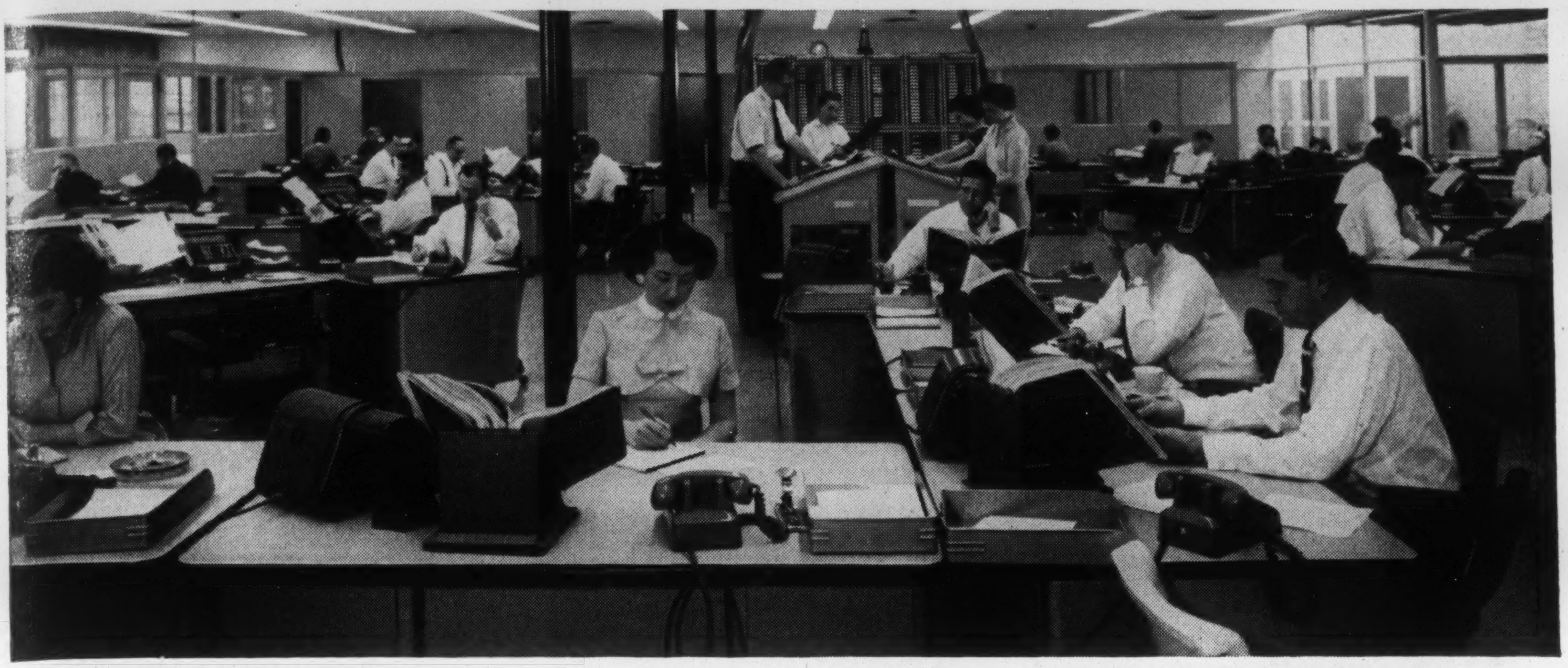
Designated UniFide, the powder has a low oxygen content (0.25%) and is stable in air. When exposed to air for three months in an open container, oxygen content of the powder only increased from 0.034 to 0.053%. According to the producer, this stability permits shipping of the powder as a dry material, unlike other titanium powders which must be shipped under water.

How Ceramic Coatings Affect Creep Rates

Refractory type ceramic coatings are being widely used to protect metal parts at high temperatures. It has been found that ceramic coatings affect the creep rates of some alloys; under some conditions, for example, a ceramic coating can reduce creep of a metal by as much as 50%.

In order to learn more about the effects of ceramic coatings on

Just pick up your phone—



get price quotations, expert advice, prompt delivery

from your Superior Warehouse Distributor

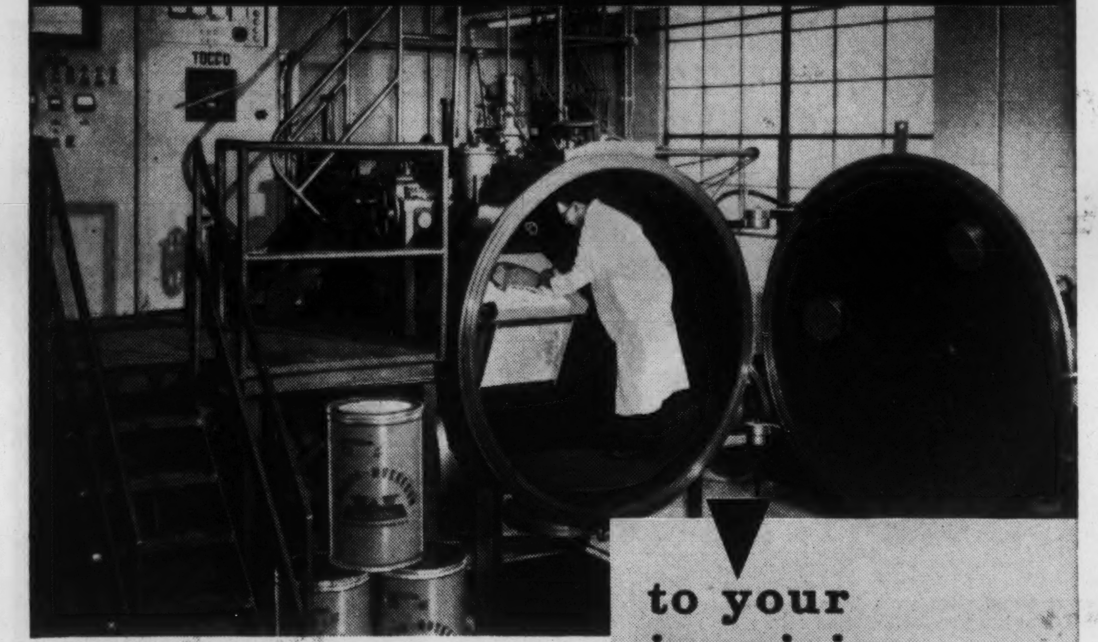
Up against a tubing problem? Call your nearest Superior distributor. He's well stocked with quality tubing and information. Often he can make money-saving recommendations. Through his contact with the mill he can expedite information and orders for you. Let him show you why Superior tubing offers you real economy. Call on him today. He can save you valuable time and money.

For general information on Superior tubing, get a free copy of Bulletin 40. Write Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Superior Tube
The big name in small tubing
NORRISTOWN, PA.

All analyses .010 to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

For more information, turn to Reader Service Card, Circle No. 584



Our facilities are open...

to your inquiries about Cannon-Muskegon VACUUM-MELTED UltraMet alloys and service

WHATEVER your metallurgical problem, Cannon-Muskegon is equipped and staffed to solve it. Our metallurgists can make the *right vacuum-melted* alloy to fit your need. We can develop and test it in the ultimate in modern research and testing laboratories . . . then produce it to specifications in our modern plant. What's more, Cannon-Muskegon recommends proper handling methods for best results in your application.

In addition, Cannon-Muskegon offers a wide range of ferrous-, nickel- and cobalt-base alloys for your specific needs. These super-clean alloys are poured at pressures from 1 to 10 microns — available in sample or production quantities . . . in cast billets or ingots. Vacuum-melted alloys offer cleaner, smoother surfaces . . . greater tensile strength, ductility and wear life . . . higher electrical and magnetic properties. For complete vacuum-melting service, see Cannon-Muskegon.

Now available are:

- ***Materials for remelt*** — under conventional air melting, inert gas, vacuum.
- ***Casting development*** — includes research and experimental facilities for investment, shell mold, dry sand, and permanent mold castings.
- ***Ingots or cast billets*** — for rolling, forging or extruding in individual weights up to 250 pounds.

MODERN RESEARCH facilities and experts are at your service. Constant research with known alloys develops our abilities . . . to your advantage. We are now testing alloys containing boron, aluminum and titanium . . . with interesting results. Send us your problems.

ULTRA MET
VACUUM-MELTED ALLOYS
FOR INDUSTRY

For full particulars write for our New Bulletin on Vacuum-Melting and Air-Melting facilities and products.

CANNON-MUSKEGON CORPORATION
2873 Lincoln Street Muskegon, Michigan

METALLURGICAL SPECIALISTS

For more information, turn to Reader Service Card, Circle No. 512

the creep rates of alloys, J. R. Cuthill, J. C. Richmond and N. J. Tighe of the National Bureau of Standard's enameled metals laboratory recently began a study of this behavior under different temperature-stress conditions.

The NBS test utilized a ceramic coating made of cerium oxide, enameler's clay and frit on two 80 nickel-20% chromium alloy metal strips machined from thin sheet metal. The alloys differed significantly in manganese, iron and silicon content. Both coated and uncoated samples were tested at various temperatures and pressures over a period of time.

What creep curves show

Creep curves of coated specimens usually remained below the curves of uncoated specimens during the first 20 hr of testing. However, coated specimens generally showed a greater rate of increase in creep than uncoated specimens beginning about 20 to 30 hr after the start of the test. This increase took place during a period of rapidly increasing creep rate, and fractures of the coated specimens usually occurred during this period. A ceramic coated specimen that did not fail under test for more than 1200 hr showed significantly greater creep after the first 100 hr than did the uncoated specimens.

No void formation was found in coated or uncoated specimens tested at 1800 F. Extensive internal voids were found in uncoated specimens tested at 1900 and at 1975 F, whereas little void formation occurred in coated specimens at either of these temperatures. A chemical analysis of an uncoated specimen showed that it lost twice as much chromium as a coated specimen tested at the same temperature.

Better when hotter

At 1900 F and 900 psi and at 1975 F and 600 psi, the creep rate of both alloys was virtually constant for the duration of the test.

(continued on p 242)

Johns-Manville presents a

NEW REFRACTORY FIBER INSULATION

for temperatures to 2000° F

J-M CERAFELT insulation . . .

controls heat more effectively in a wide variety of high-temperature industrial services!

Cerafelt® is one of the most recent achievements of Johns-Manville insulation scientists . . . developed specifically for the new high-temperature processes now being employed in the metallurgical, chemical, ceramic and allied industries.

Particularly important in these applications is Cerafelt's infra-red opacity, an advantage that accounts for its unusually low *k* factor at elevated temperatures. Another important advantage is fineness of fiber structure. With fibers averaging only 3 microns in diameter, Cerafelt contains far more heat-blocking air pockets per cubic inch. Hence, it offers far better insulating effectiveness at high temperatures!

Cerafelt is non-alkaline, chemically stable, and contains no corrosion-promoting agents. For information write to Johns-Manville, Box 14, New York 16, N. Y.
In Canada, Port Credit, Ontario.

Johns-Manville
INSULATIONS
for lasting thermal efficiency

DENSITIES, SIZES & THICKNESSES

Type	Density lbs. per cu ft		Available Thickness inches		
CRF300	3	¼	½	¾	1
CRF400	4	¼	½	¾	1
CRF600	6	¼	½	¾	1
CRF800	8		½	¾	1
CRF1000	10		½	¾	
CRF1200	12		½		

STANDARD SIZES:
Length: Regularly furnished in 3, 4, 5, 6 and 8 ft. lengths. CRF300 through 800 (except in 1" thickness) also furnished in 26 ft. lengths.

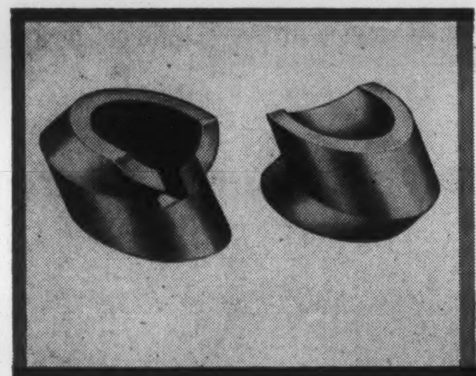
Width: 42 inches (untrimmed).

In loose fiber form the material is known as J-M CERAFIBER; shipped 10 lbs. per bag.

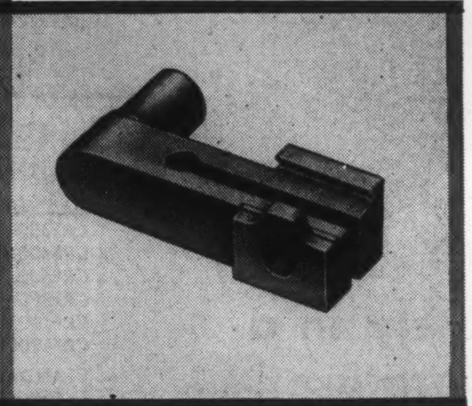
For more information, turn to Reader Service Card, Circle No. 568

Basic Considerations in Selecting alloys . . . . . for your INVESTMENT CASTINGS

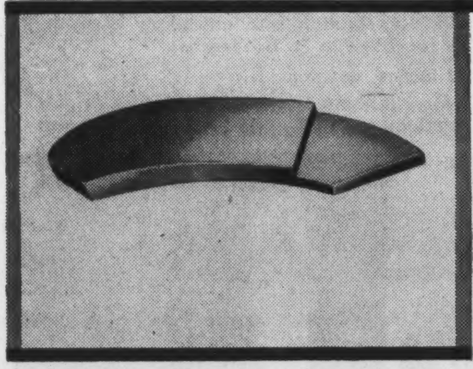
DO YOU KNOW THAT . . . an investment casting produced from a low cost metal may be MORE EXPENSIVE than one cast from higher priced material that may also have characteristics better suited to your requirements.



These angle connectors were originally investment cast in mild steel, a low cost material. To overcome corrosion problems, 303 stainless was substituted and because of its better castibility there was no increase in cost. Now, silicon brass is being used at a 10% saving on the original selling price.



This gage mount is an excellent example of unusually good casting characteristics of one metal offsetting a decidedly higher material cost. Originally priced in SAE 8620 steel, it was changed to beryllium copper at a 15% saving in unit price.



This simple textile machine part requires a high degree of wear resistance. Casting in the right metal provided better properties at lower cost than when machined from tool steel.

Get more complete information for this is only a small part of the story telling how the right metal selection for investment castings can often increase efficiency and reduce costs.

WRITE today for Bulletin 116-205 . . . it's FREE!

HITCHINER
Manufacturing Company
MILFORD 7, NEW HAMPSHIRE
REPRESENTATIVES IN PRINCIPAL CITIES

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At 1800 F and 2200 psi, the initial creep rate was comparatively low—well below that of the uncoated specimens, but after 20 to 30 hr the creep rate increased rapidly for a few hours and then became gradually less again.

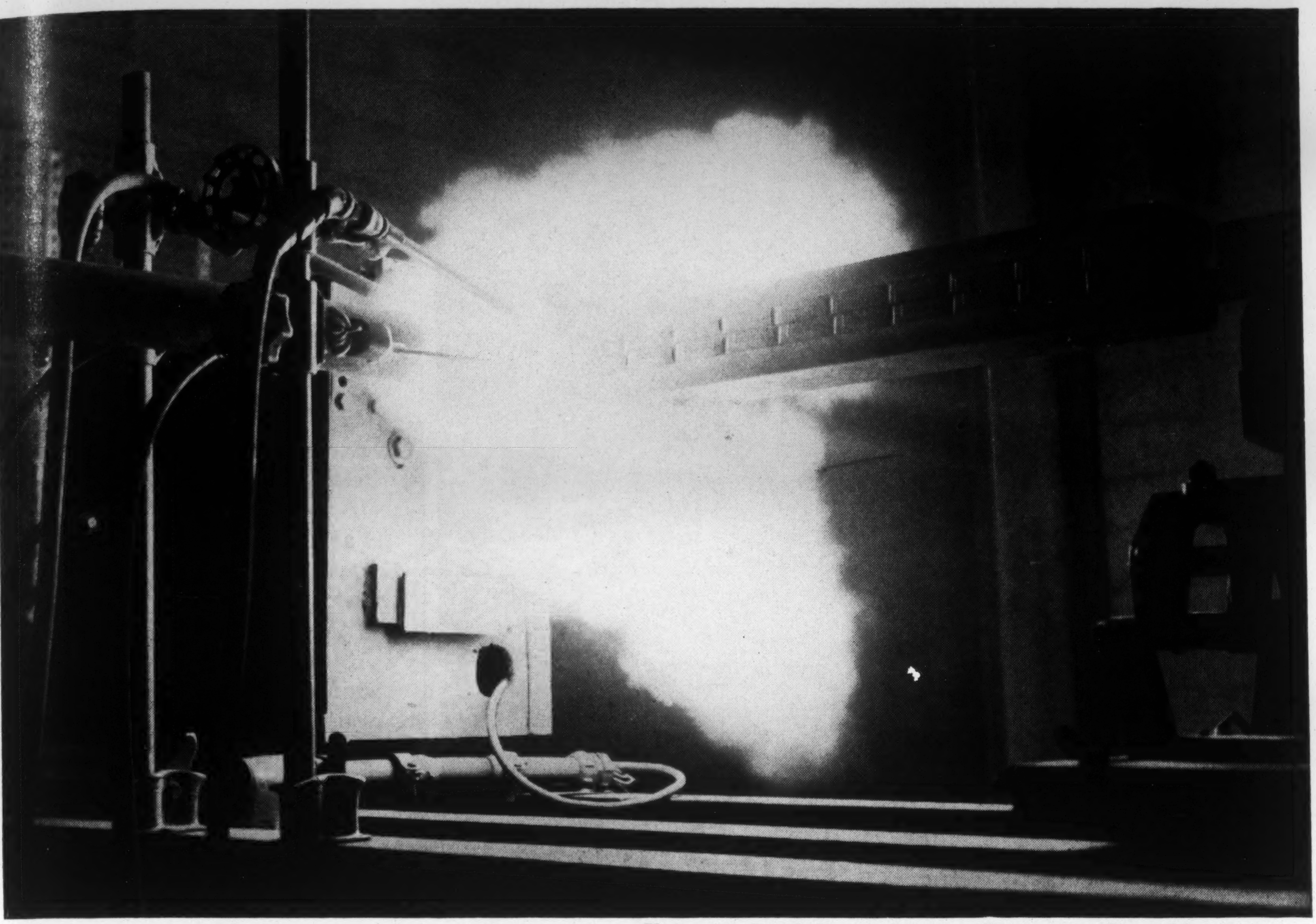
The test results suggest that ceramic coatings are not sufficiently fluid at 1800 F to follow the deformation of the specimen when a stress of 2200 psi is applied. Profuse cracking of the coating occurred in all of the coated specimens that failed at 1800 F and 2200 psi, but in no other specimens. Presumably, at higher temperatures the ceramic coating is more plastic than at lower temperatures and is able to follow the deformation of the specimen at strain rates as high as those which result in failure at the lower temperatures.

Auto Crankshafts Cast of Pearlitic Iron

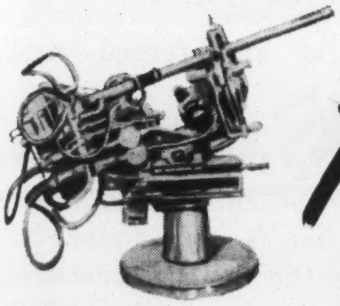
The successful use of cast pearlitic malleable iron for large parts has resulted from 1) additions of bismuth to the molten iron to increase the section size of parts that can be cast in the white condition and 2) additions of boron to facilitate precipitation of temper carbon. As a result of these developments and recent improvements in shell molding techniques, General Motors Corp. specified pearlitic malleable iron crankshafts for its Pontiac cars. Now, after a substantial production run, D. B. Valentine has gathered information on some of the characteristics of the iron crankshafts. He presented his findings at the annual meeting of the Society of Automotive Engineers held in January. A summary of some of his findings:

Modulus of elasticity—Although forged steel crankshafts possess a higher modulus (29 million psi compared to 24-26 million psi),

A LOW-POROSITY, WEAR-RESISTANT ALUMINUM OXIDE COATING



Visit us in Booth No. 1005, Design Engineering Show, May 20-23.



Flame-Plating by Linde

Trade-Mark

LINDE's Flame-Plating method of coating metal surfaces now provides extra wear resistance for parts subject to extremely hard wear and high temperatures. This new high-purity aluminum oxide coating, blasted from the Flame-Plating gun, builds up on the workpiece in desired thicknesses from .002 to .040 inch. With a porosity of *less than 1 per cent*, the aluminum oxide coating can be used at temperatures up to 1750 degrees F.

The hardness of aluminum oxide coatings, Flame-Plated by LINDE, ranges from 1000 to 1200 VPN. Metallurgical properties of the base metal are not modified by the Flame-Plating process because the part being plated always remains at a temperature of 400° F. or below. The bond between coating and base metal is exceptionally strong with aluminum. Aluminum oxide coatings can be used in as-coated condition (approximately 120 microinches rms), or finished to better than 1 microinch rms.

Flame-Plated coatings of aluminum oxide provide resistance to wear, and to chemical action in high temperature applications. Applications are found in thrust bearings, pump plungers, thermocouple tubes, gas turbines, guided missiles, and other devices. Either aluminum oxide or tungsten carbide can be Flame-Plated on most metals. If you have a special wear problem, LINDE's Flame-Plating Department will gladly help you to reach a solution. Write to "Flame-Plating Department N-4."

LINDE AIR PRODUCTS COMPANY

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, New York

In Canada: Linde Air Products Company, Division of Union Carbide Canada Limited, Toronto

The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

Flame-Plating by Linde

For more information, turn to Reader Service Card, Circle No. 438

Product Improvement with one of 400 Presstite Sealants

spot-welded seams are water, moisture and dust tight when sealed with . . .

PRESSTITE MASTIC SEALERS

Here are the cold facts about Presstite cold-applied Mastic Sealer No. 525:

- Specially designed for sealing spot-welded seams and joints to sides and bottom of refrigerator cabinet —as shown in the application above.
- Easily applied directly with heavy-duty pump.
- Lasting adhesion and plasticity on all types of materials.
- Non-corrosive, free from objectionable odor.

WRITE for a working sample and technical data. No obligation.

Manufacturers of Sealing Compounds Exclusively Since 1924

PRESSTITE SEALING COMPOUNDS
PRESSTITE-KEYSTONE ENGINEERING PRODUCTS COMPANY
KAP

A Division of AMERICAN-MARIETTA COMPANY
3916 CHOUTEAU AVENUE, ST. LOUIS 10, MISSOURI

For more information, turn to Reader Service Card, Circle No. 554

similar torsional vibration characteristics are obtained by modifying the design of the pearlitic iron crankshaft. Tests have shown that the lower modulus is no detriment to smoothness of engine operation at normal car driving speed.

Fatigue properties — Dynanometer tests and 100,000-mile road tests show comparable endurance of forged and cast crankshafts. Variations in notch sharpness have no effect on fatigue properties.

Tensile strength — Standard ASTM 505 tensile test bars, machined from journals and counterweights of pearlitic malleable iron crankshafts, possess 96,000 psi tensile strength at 228 Brinell hardness. This figure compares with 114,000 psi obtained from 1046 SAE steel.

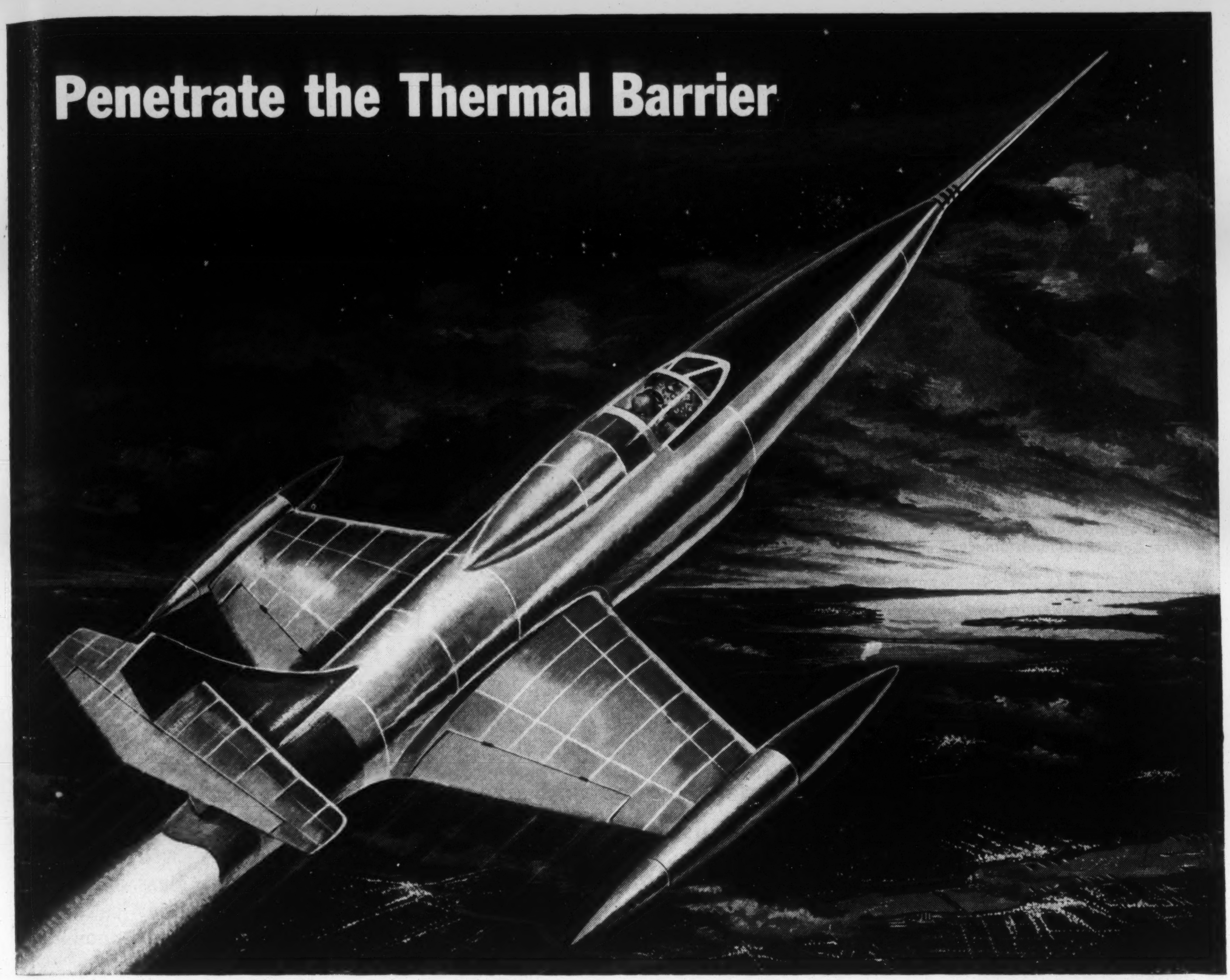
Wear characteristics—There is no appreciable difference in pin and journal wear between cast crankshafts and forged crankshafts.

Machining—On the basis of 59,000 forged steel crankshafts and 49,000 pearlitic malleable iron crankshafts, it was found that with iron the tool life increased, the number of grinding wheels necessary decreased and the feed rate increased.

Epoxy-Base Enamel for Dark Phenolic Parts

Dark colored phenolic parts, such as telephone handsets (see photo) and electric iron handles, can now be colored economically and permanently without using primers or multiple coats. This is possible through the use of a new epoxy-base enamel developed by Rexton Finishes, Inc., Irvington, N.J. Thermosetting parts rejected for color contamination can be salvaged by application of this epoxy-base finish.

Intended primarily for use on phenolics, the new enamel is said



MicroMach *extra-high-tensile stainless steel sheets up to* **48" WIDE** *for aircraft and missile use*

As the speed of today's aircraft rapidly approaches the Thermal Barrier, conventional metals are being left far behind in the race to satisfy the structural requirements of supersonic craft. Needed are metals that can withstand the intense heat caused by air friction at high speeds and still retain their strength. One such metal, MicroMach stainless, has been in use for more than a year.

MicroMach is a special aircraft and missile grade of modified type 301 stainless steel sheet furnished to higher mechanical properties than are available in other commercial high tensile grades in the full hard condition.

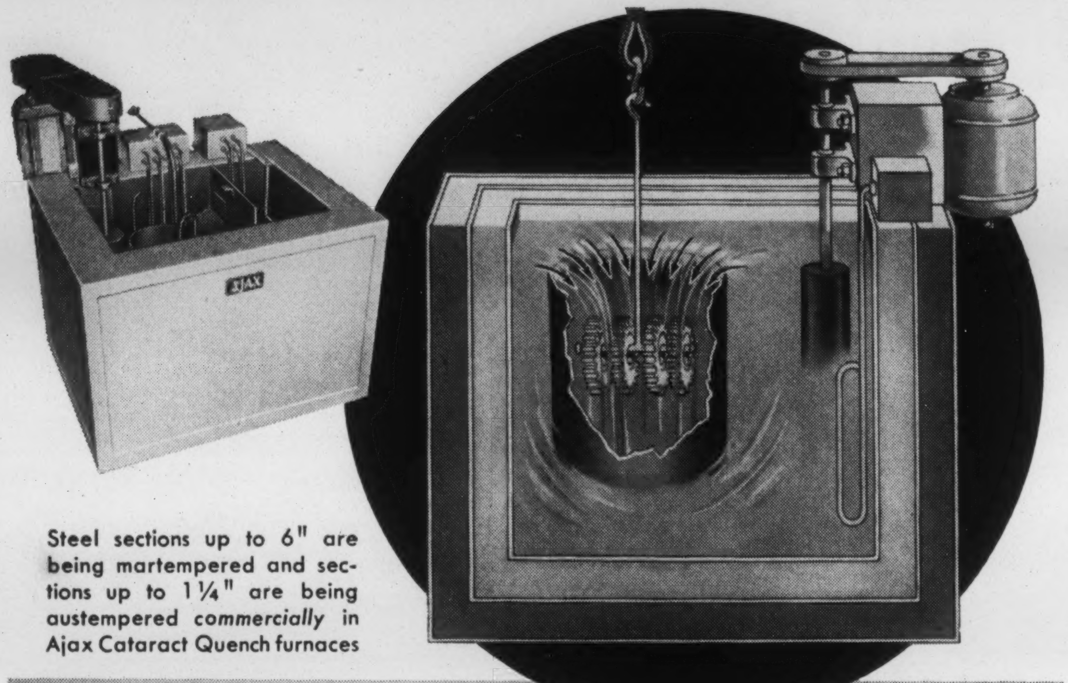
These sheets are rolled to extremely close tolerances (as low as plus or minus 3%) with micro-accuracy and precise uniformity of gauge. The surface of MicroMach sheet is smooth, clean and dense; qualities so important in minimizing surface friction.

For further information write to Aircraft Steels Dept.

Washington Steel *Corporation*
4-F WOODLAND AVENUE
WASHINGTON, PA.

MicroRold stainless steel is also available in all popular grades and to meet regular government specifications. Sheets up to 36" wide can be had as thin as .005", and over 36" to 48" wide as thin as .010" in all commercial finishes and tempers.

For more information, turn to Reader Service Card, Circle No. 524



Steel sections up to 6" are being martempered and sections up to 1¼" are being austempered *commercially* in Ajax Cataract Quench furnaces

A BIG STEP AHEAD IN ISOTHERMAL QUENCHING

AJAX
HULTGREN

Salt Bath
CATARACT®
QUENCH
Furnace

...even for steel shapes and sizes that couldn't be austempered or martempered satisfactorily before

The quenching power of molten salt at 400° F. and above is tremendously increased by the rushing flow created in this unique Ajax "Cataract" furnace design. As a result, any steel that can be hardened satisfactorily by an oil quench can now be martempered or austempered in salt—*with all of the salt bath advantages.*

These include more uniform hardness; so little distortion that parts can usually be finish machined *before* hardening; elimination of quench cracks; and increased toughness and ductility. Also, like all salt baths, Ajax Cataract Quench Furnaces are readily mechanized.

WRITE for Ajax Martempering and Austempering case history bulletins.

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906 FRANKFORD AVE. PHILADELPHIA 23, PA.
Associates: Ajax Engineering Corp.
Ajax Electrothermic Corp.

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CLEVELAND 13, OHIO: Anderson-Bolds, Inc., 2021 W. 25th St.
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ELMHURST, ILL.: O. M. Haseltine, 129 N. York St.
GLENSIDE, PA.: John P. Clark, Jr., 124 S. Easton Rd.
GOSHEN, OHIO: Ralph D. Hawkins, Box 196
HAMDEN 18, CONN.: Joseph M. Halloran, 63 Mowry St.
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MOUNTAIN LAKES, N. J.: Roger Stuart Brown, 7 Point View Place
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NEW YORK 6, N. Y.: Roger Stuart Brown, 136 Liberty St.
ORINDA, CALIF.: George H. Thurston, 1 Estates Court
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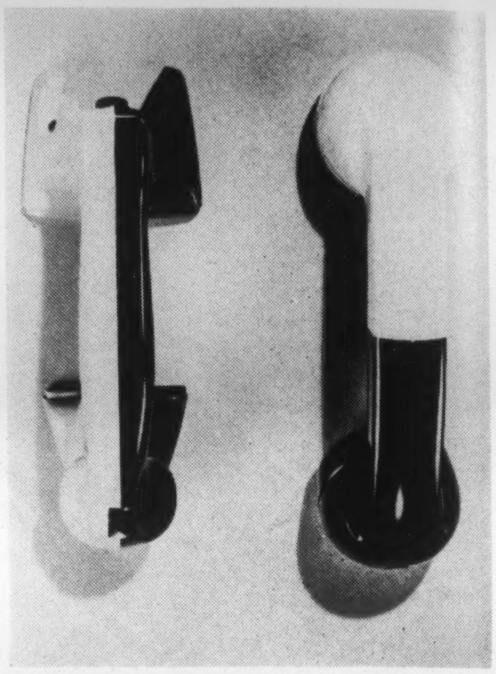


***Light colored** epoxy-base enamel covers dark colored phenolic part with one coat.*

to work equally well on steel, brass, aluminum, glass and other plastics. The supplier estimates cost of applying the enamel at about 1¢ per sq ft.

The enamel is fast drying and permits the handling of air dry pieces in about 2 hr. It is available in a variety of finishes and colors, including clear and metallic.

Cast Acrylic Sheets Made Extra Large

Extra large, cast acrylic sheets, in sizes up to 8½ x 10 ft, are available in both clear and colored sheets from Rohm & Haas Co., Washington Square, Philadelphia 5. Called Plexiglas RL, the sheet material is designed for use in internally illuminated signs, fluorescent luminaires and skylights.

It is supplied as untrimmed, unmasked sheets in standard packages of varying weights, depending on thickness and size of sheets. The sheets are available in thicknesses of 0.187 and 0.250 in. and in the following sizes: 72 x 100, 84 x 84, 96 x 96 and 102 x 140 in.

(more What's New on p 248)

Is there a job for CO_2 in your plant?

Almost every day another manufacturing or processing plant finds that carbonic gas can improve the product — simplify an operation — cut costs or increase safety.

The applications briefly discussed here are just a very few of the hundreds for which CO_2 is being used today. Some of these may be of direct interest to you, others may be adaptable to your field. If you'd like a broader list, we'll be glad to send you our booklet "CO_2 Applications Unlimited." Just check it on the coupon below. If you'd like detailed technical data on any of the applications listed in this advertisement check those in the coupon too.

CURING CORES AND MOLDS FOR FOUNDRY CASTINGS—Ordinary foundry sand cores can be cured in 20 seconds flat, molds cured in an unbelievably short time. CO_2 gas reacting on a special sand binder gives an instantaneous chemical reaction . . . eliminates baking, gives sound, hard, perfectly formed cores and molds of any shape or size. CO_2 curing gives more accurate dimensions, too. CO_2 cured molds can be left for several days before pouring.

ECONOMICAL GAS SHIELDED WELDING—Costing only 1½ cents per cubic foot, CO_2 gas replaces expensive argon or helium gas in metal-arc gas shielded welding operations. Users report saving an average of seven cents per cubic foot of gas. Low-cost CO_2 also produces welds that are equal, or superior, to welds made with argon or helium gas. No expensive installations are necessary . . . present equipment can often be used "as is" or with modifications.

RUBBER TUMBLING—Flash or rind is quickly and smoothly removed from molded rubber parts by tumbling them in a CO_2 tumbling barrel. The parts are frozen with either dry ice or liquid CO_2, which is expanded directly into the tumbling barrel. As parts may be tumbled in large quantities, production costs are greatly reduced by this method over hand-trimming. Liquid also manufactures and sells the finest, most efficient, insulated tumbling barrel for this purpose.

PAINT AND VARNISH MANUFACTURE— Sparged up through the oils during the cooking process, CO_2 gas performs two important functions. Used in conjunction with conventional mechanical agitation, CO_2 sparging cuts oil cooking time as much as 60%. In addition to markedly increasing agitation, the CO_2, as it passes through the mixture, actually "sweeps" unwanted moisture along with it allowing the cooking mixture to reach a higher temperature. CO_2 is also used to advantage in the thinning, storage, filtration and other phases of paint and varnish manufacture.

INERTING—
There are many times when an inert atmosphere is needed to prevent fire or explosion. Before welding a tank that has been used for the storage of flammable liquid, CO_2 is used to inert the atmosphere in the tank so that welding can be done with no danger of explosion.

WEAK ACID—
CO_2 is used in the textile industry and many other applications as a weak acid for neutralizing.

FREEZE-DRYING—
Freeze-drying is used to dehydrate heat sensitive substances at low temperatures. In the manufacture of Pharmaceuticals dry ice is used to condense the moisture as it is sublimed under vacuum.

World's Largest Producer of
THE LIQUID CARBONIC CORPORATION
Chicago 23, Illinois

☐ Curing Cores and Molds
☐ Gas Shielded Welding
☐ Rubber Tumbling
☐ Paint and Varnish Manufacture
☐ Freeze-Drying
☐ Weak Acid
☐ Inerting

THE LIQUID CARBONIC CORPORATION
3172 South Kedzie Avenue • Chicago 23, Illinois

☐ Please send me a copy of "Applications Unlimited". I would also like more detailed information on the uses of CO2 as checked.

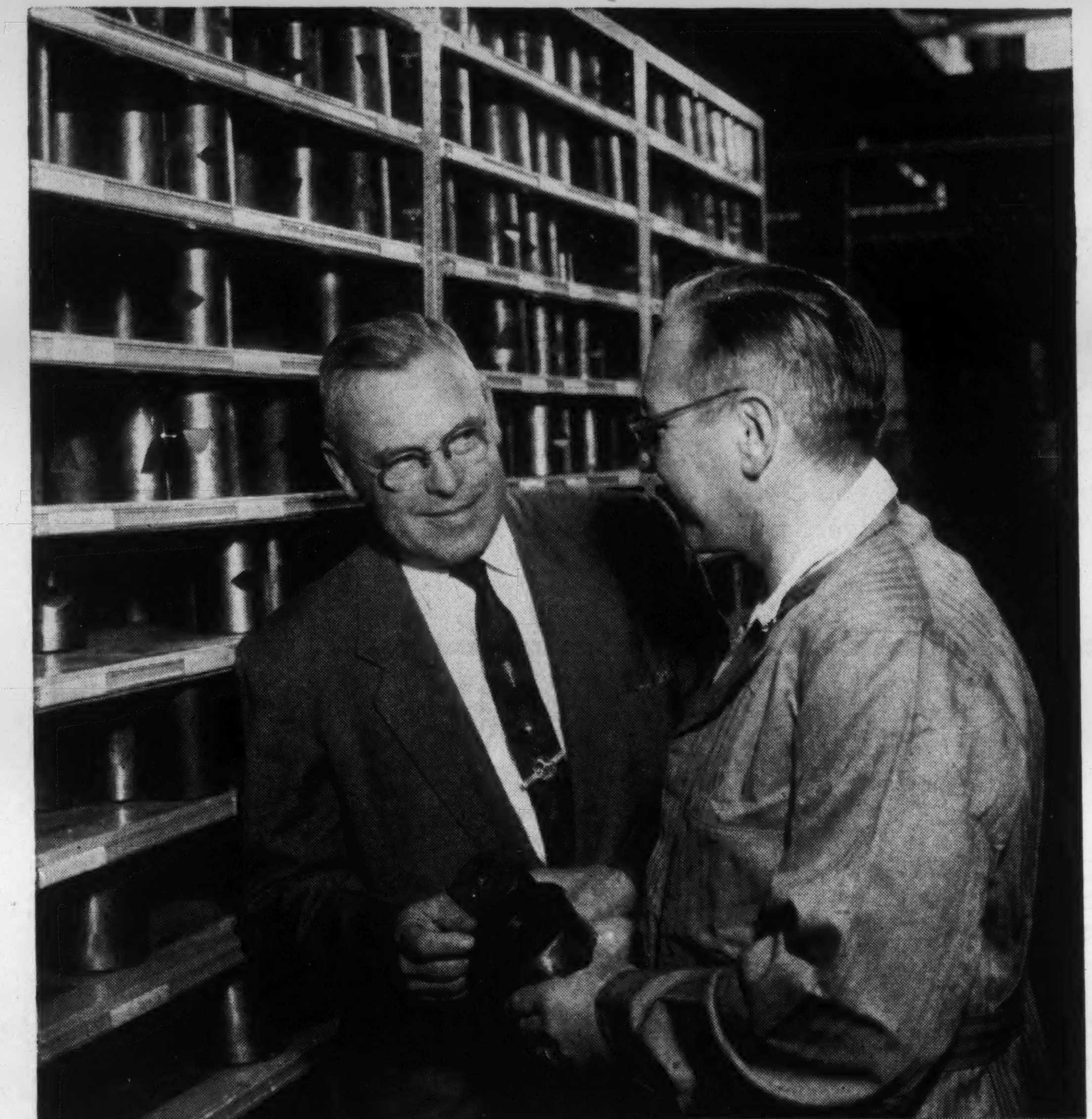
Name__________

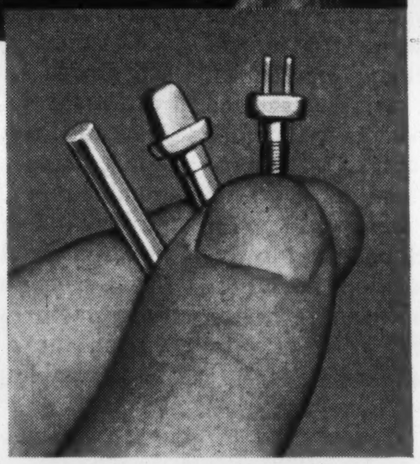
Title______ Company__________

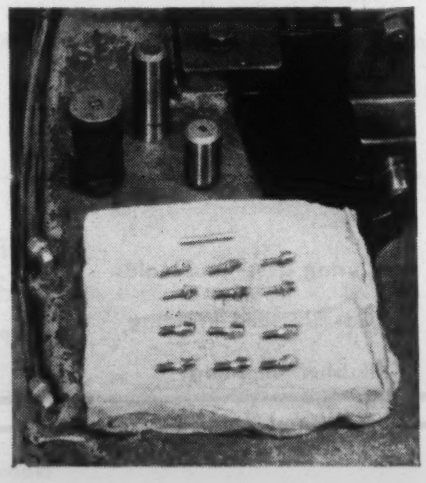
Address__________

City__________ Zone___ State_____

For more information, turn to Reader Service Card, Circle No. 567







VULCAN Tool Steels get results:

Production up, costs down

A major tool steel user—H. M. Harper Company—recently came up with a real "toughy": Dies for cold heading slotted, hard-to-work Nickel terminal screws. Harper tested steels of various analyses for the application. They found that Vulcan Special Vanadium filled the requirements exactly.

The result—terminal screws produced by cold heading process instead of milling — at very substantial increases in production and much lower cost.

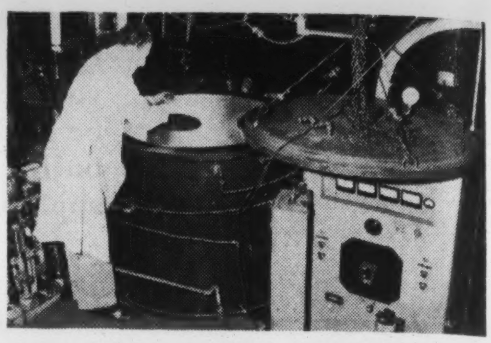
Vulcan representatives *like* tough problems. They welcome highly-demanding tests of Vulcan tool steel superiority. They enjoy tackling a variety of problems, because Vulcan's complete line of fine quality tool steels allows them to give *right answers*—not "almost as good" recommendations.

VULCAN Special Vanadium used for cold heading dies that are tough enough to produce slotted Nickel terminal screws at H. M. Harper Company, Morton Grove, Illinois.

A representative is near by to serve you. *Vulcan Crucible Steel Division, H. K. Porter Company, Inc., Aliquippa, Pa.*

HKP VULCAN CRUCIBLE STEEL DIVISION
H. K. PORTER COMPANY, INC.

For more information, turn to Reader Service Card, Circle No. 611



Vacuum sintering furnace *where complex carbide tool blanks are hardened.*

Tungsten Carbide Parts Made by New Process

Sintercast Corp. of America is using a new process to make intricately shaped, cemented tungsten carbide tool blanks that are said to be true-to-shape. The new process produces a part having uniform density in the presintered form so that after shaping and high temperature sintering it retains its shape and dimensional stability.

The pressing technique consists of three operations: 1) hydrostatic compacting, which applies equal pressure to the tungsten carbide powder from all directions; 2) projection grinding to produce exact shapes and precise dimensions; and 3) sintering in a vacuum furnace to harden the part.

Structural Efficiency of Steel 'Sandwiches'

New data on the structural efficiency of stainless steel sandwich plates is becoming increasingly essential as new developments in high speed aircraft and missiles rule out the use of lighter metals. Fabrication difficulties, which previously limited the use of this high strength cellular core material, have now been overcome and the only remaining question concerns the efficiency of the sandwich materials.

In Technical Note 3751 of the

UNICHROME
Trade Mark

News about

COATINGS for METALS

Metallic.........Organic.........Decorative.........Protective

Simple bronze plating process gives gold-like finish

- ***M&T copper-tin process deposits extraordinary, golden-glow decorative plate . . .***
- ***Also cuts need for nickel as undercoat***

Bronze plating has proved itself a practical finish in large and small installations. The copper-tin process developed by Metal & Thermit eliminates usual difficulties and disadvantages in alloy plating. It is as easy to operate and control as normal processes depositing a single metal.

Equally important, this bronze can be deposited with brilliant 24K gold color by using a trouble-free brightener. Protected with a clear organic coating, it provides a high quality decorative finish with unusual appeal and long life. Overall cost of this bronze rivals that of copper and is less than that of a brass plate.

M&T Bronze gets the trophies. Golden-glow finish for die cast trophy cups wins over copper-nickel-gold formerly used by leading producer.

VALUABLE UNDERCOAT

As an undercoat, M&T Bronze has these qualifications: Good corrosion resistance; hardness better than copper and virtually equal to nickel; more ductility than nickel.

Undercoat-bronze can be plated semi-bright or matte. Both buff more readily than copper and with less chance of cut-through on edges.

OPERATIONAL ADVANTAGES

M&T Bronze offers better than twice the speed of fast copper plating solutions. There are numerous installations working at normal current densities of 60-75 amps per sq. ft. Densities of 100 amperes deposit over one-tenth mil a minute smoothly.

Golden-glow bronze delivers uniform color on intricate decorative work. So outstanding is its throwing power, it is being used to replace copper on complex automobile parts. It uses single anode circuits, and copper anodes which corrode uniformly. The tin is supplied by potassium stannate additions, assuring simple, economical control of the process.

For an unusual finish, both in appearance and protective function, the golden-glow M&T Bronze Process offers interesting possibilities to metal finishers and designers. Send for data.

New economy in chromate finishing

Several newly developed Unichrome Dip Compounds work at extreme dilutions. They offer chromate solutions with still lower make-up and operating costs than previously delivered by economical Unichrome Dips. These new Dips make it practical to preserve shelf life and appearance of galvanized, zinc plated or die cast items, even those having low unit price or narrow margin of profit.

MATCHED TO THE NEED

Unichrome Dip Solutions form corrosion-resistant finishes integral with zinc, improve and protect its eye appeal.

But chromate dips are active solutions which strip away zinc as well as convert its surface into an attractive but inactive film. As a result, the type of equipment used and the operating time or cycle affect results. The differing needs of manual or automatic finishing must be satisfied to produce the color, corrosion resistance, uniformity of finish—as well as the economy desired. Since no single chromate solution is equally suitable for all applications, many specialized Unichrome Dip Compounds are made available.

Metal & Thermit will gladly recommend the proper dip to meet specific needs. Simply submit details of product and requirements.

Unichrome is a trademark of Metal & Thermit Corp.

METAL & THERMIT
CORPORATION
General Offices: Rahway, New Jersey
Pittsburgh • Atlanta • Detroit
East Chicago • Los Angeles
In Canada: Metal & Thermit—United Chromium of Canada, Limited, Rexdale, Ont.

For more information, turn to Reader Service Card, Circle No. 555

determine carbon potential

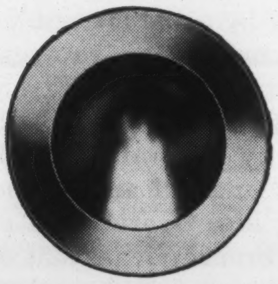
detect
- restricted flow of atmosphere
- leaky furnace seals
- transient moisture and air from quench tank
- air carried into the furnace with the charge

with the DEWPOINTER

Quick and accurate readings of dewpoints in each furnace zone give the heat treater the most valuable information possible for accurate adjustment of furnace atmosphere.

In one relatively inexpensive unit, the Dewpointer brings you this accurate data with simple operations. Any shop man can get precise readings every time—for the maximum in effective furnace control.

Only the Alnor Dewpointer gives you controlled test conditions...indications take place in an enclosed chamber. Dew or fog is suspended in the air as sunbeams—not on a polished surface. This unique principle gives you the greater accuracy, faster readings required for critical heat treating atmosphere control.


Eliminate Guesswork
Here's what you actually see with a Dewpointer—a swirl of sunbeams that is unmistakable in reading. Find out why so many use the Dewpointer for atmosphere control. Send for your copy of the illustrated Dewpointer Bulletin. Write: Illinois Testing Laboratories, Inc., Dept. 522, 420 North LaSalle Street, Chicago 10, Ill.

Alnor

ILLINOIS TESTING LABORATORIES, INC.

For more information, turn to Reader Service Card, Circle No. 463

What's new IN MATERIALS

National Advisory Committee for Aeronautics, Aldie E. Johnson, Jr. and Joseph W. Semonian present data comparing the efficiency of optimum-proportioned steel sandwich plates with that of solid plates of high strength steel, aluminum and titanium alloys when subjected to compressive end loads at temperatures of 80 and 600 F. Their tests showed that:

1. Comparative efficiency of a steel sandwich plate increases with decreasing core density at first, but as the core density is reduced below about 2% of that of the facing material, shear stiffness of the core becomes an important factor and finally results in a decrease in efficiency at higher loads. At low loads, little efficiency is gained by reducing core density below approximately 2% of that of the facing material. At high loads, core densities approximately 5% of that of the facing material are near the optimum.

2. At room temperature, it is possible to make steel sandwich plates that are more efficient than solid plates of titanium alloy over the entire loading range considered, and more efficient than solid plates of aluminum alloy over the lower part of the loading range. Steel sandwich plates maintain their advantage over solid titanium alloy at 600 F. At low loads the efficiency of steel sandwich plates is greater at 600 F than the efficiency of solid plates of aluminum or titanium alloys at 80 F.

3. The proportion of the weight of the core material in relation to the weight of the complete sandwich decreases with increasing loads. Except for low compressive loads, the core thickness in steel sandwich plates of efficient design is small; consequently, the weight of the core material is only a small percentage of the weight of the sandwich plate.

(more What's New on p 252)

NEW HAMMARLUND RADIO RECEIVER

FEATURES DIE CAST PANEL

HAMMARLUND
HAMMARLUND

CASE HISTORIES FROM
MT. VERNON FILES

In their new HQ-100, Hammarlund Manufacturing Company brings to reality a completely new concept in receiver design. It is beautiful. It gives the radio amateur the utmost in performance. And it sells for far less than other comparable short-wave receivers.

A chief reason for this great economy is the front panel—the first die-cast panel in the history of commercial radio equipment. This 3-dimensional, channeled die-cast aluminum panel is used because it affords both rigidity and great structural strength. To produce its equivalent in sheet metal —the currently used method in the industry—*would cost 4 times as much.*

This remarkable panel is the result of thorough collaboration between Hammarlund and the die-making experts at Mt. Vernon, who made practical suggestions which simplified its design.

In addition to the production economies of die casting, the panel benefits from these other important advantages: (1) Die casting's inherent accuracy enables Hammarlund to assemble the chassis with what they call "camera precision construction." (2) All rejects on the production line are eliminated. (3) In finishing—die casting enables them to work out clearly divided areas for the elegant two-tone treatment that is both functional and beautiful. Also, the amount of finishing is minimized.

When you are out to break precedent, as Hammarlund did, you too can find the kind of skilled help you need in the complete service available from Mt. Vernon's coordinated designing, die-making, casting, and machining facilities, all under one roof, which can supply die cast zinc and aluminum parts ready for use. A switch to a die casting service like ours may be your next step. Let's discuss it.

MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

SALES REPRESENTATIVES

Mr. Jerome J. Theobold
9 East Genesee St., Skaneateles, N. Y.

Mr. Anker Anderson
Cascade Road, Stamford, Connecticut

Mr. David King
230 Grant Boulevard, Syracuse, N. Y.

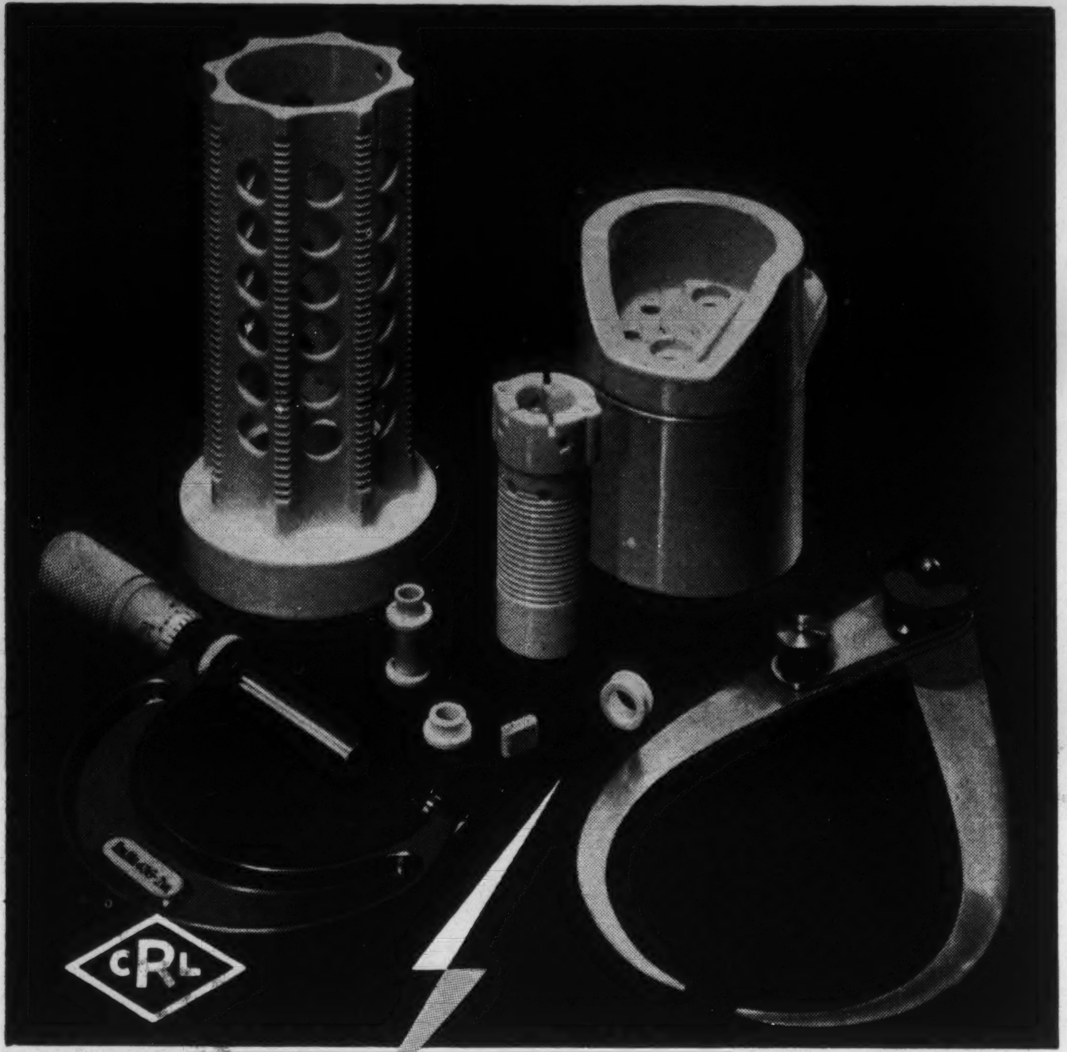
Mr. Grant Eller
6 East 194th St., Cleveland, Ohio

Mr. Arthur Diamond, Tools Incorporated
86 Bethlehem Pike, Philadelphia, Pa.

Mr. William Sauers
101 Briarcliff Road, Rochester, N. Y.

Mr. George E. Hahl
39 South Munn Ave., East Orange, N. J.

For more information, turn to Reader Service Card, Circle No. 380



Grade L-6 (Body 306) Steatite Ceramics

Small and large parts held to extremely close tolerances by Centralab

Can be extruded or molded

Can be worked the same as metal—ground, drilled, threaded or tapped

Can be metallized with fired-on-silver

See Centralab's new products in Booth 1225 at the WESCON Show

- High dimensional stability.
- Modulus of rupture, 20,000 psi.
- Water absorption less than 0.1%.
- Safe operating temperatures at continuous heat, 1500° F.
- Freedom from cold flow.
- Abrasion-resistant.
- Hardness greater than 7.5 Moh's scale.
- Loss factor only .00395 at 1 megacycle per second.
- Dissipation factor les than .002.
- Dielectric constant of 5.27 at 1 megacycle per second.
- Chemically inert.
- Freedom from carbonization.

Refer to Centralab's Ceramic Buyer's Guide in Sweet's Product Design File — or write for your personal copy. Ask for Bulletin 42-221.

Centralab® A DIVISION OF GLOBE-UNION INC.
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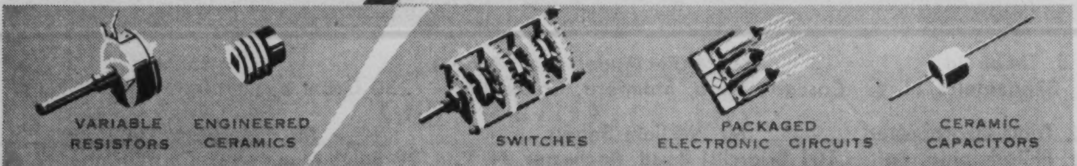
946D East Keefe Avenue • Milwaukee 1, Wisconsin
In Canada: 804 Mt. Pleasant Road, Toronto, Ontario



For more information, turn to Reader Service Card, Circle No. 589

What's new IN MATERIALS

Small Teflon Tubing for Electronic Parts

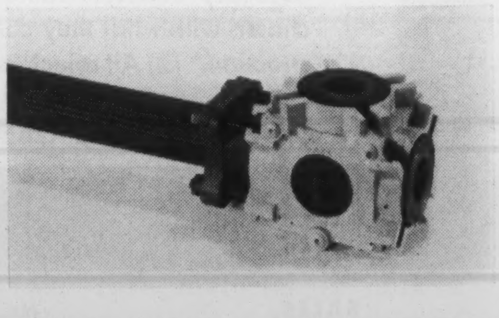
Teflon spaghetti tubing, available from Polymer Corp. of Pennsylvania, Reading, Pa., is now being produced in AWG wire sizes of 0, 1, 2, 3, 4, 5, 6, 7 and 28 and 30. Known as Polypenco tubing, it is used as a low and high frequency insulation sleeving for electronic parts. It has a minimum dielectric strength of 750 V per mil, a dielectric constant of 2.0 and a surface resistivity above 10^{12} ohms per cu cm. All sizes are available in ten coded colors for circuit identification.

Glass Fabric Covering Used on Graphite Pipe

Carbon and graphite pipe and fittings are now available with an external glass fabric covering. The covering strengthens the pipe, holds line pressures and prevents leakage in case of pipe breakage. Called Karbate armored pipe, it is available from National Carbon Co., 30 E. 42nd St., New York 17, N. Y. in 1 to 4-in. dia and lengths up to 9 ft, with either flanged or plain ends. Armored fittings are available as 90-deg elbows, tees, couplings and flange collars.

The carbon and graphite pipe and fittings are corrosion resistant and are free from metallic contamination. They are also resistant to thermal shock and easy to install.

(more What's New on p 254)



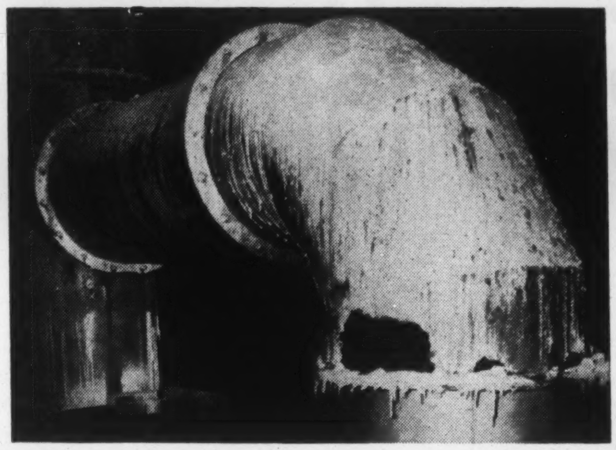
***Metal housing** protects graphite fitting from external mechanical stresses.*

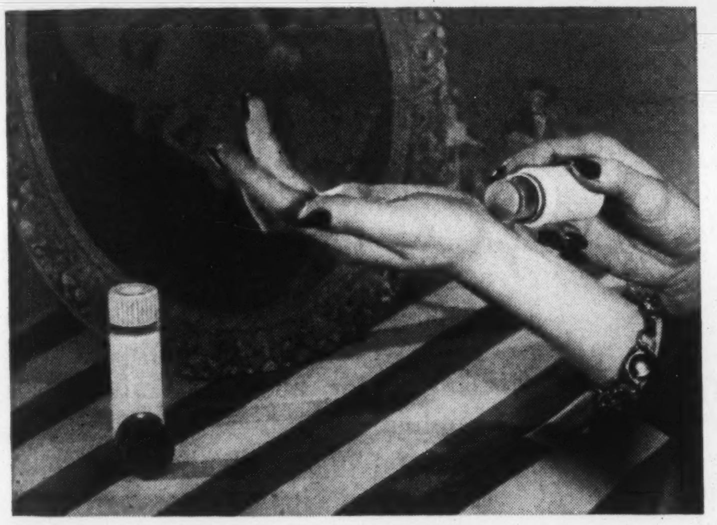
CYANAMID

PLASTICS NEWSFRONT

THREE YEARS IN CORROSIVE SERVICE WITHOUT MAINTENANCE

That's the record established by reinforced LAMINAC® polyester resin in venting service on alum digesters at Cyanamid's Warners plant. The carbon steel breech (left) in an alum evaporator required frequent maintenance, failed after less than three year's service. Glass-reinforced LAMINAC stacks (right) in even more severe alum digester service, have needed no maintenance in more than three years. The LAMINAC units cost less in the long run, and were easier to erect and assemble, using either telescope joints wrapped and polyester-welded on the site, or flange-type joints.





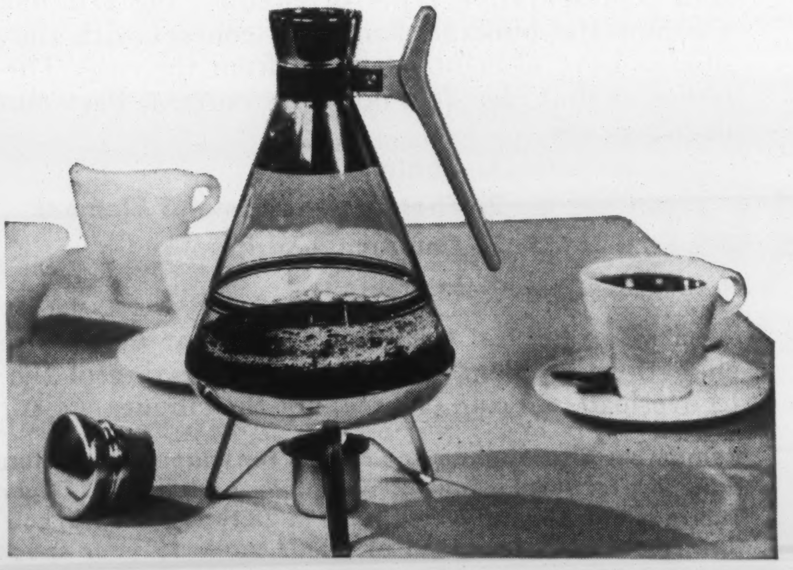
ATTRACTIVE, AIRTIGHT CASE FOR STICK COLOGNE

Six new scents of Avon Stick Cologne are packaged in smartly styled, practical cases molded of BEETLE® urea molding compound. Cases have a white base with contrasting closures in a different color for each scent. Airtight, the BEETLE case stops evaporation of the cologne. Yet the closure opens easily, and with a twist of the wrist the stick pops up for use. The case resists alcohol, essential oils and chemicals as well as staining from perspiration and grime, which wipe off easily.

FUNCTIONAL HANDLES GRACE CARAFES

Any dining or buffet table would be graced by this attractive carafe with its stylish, beige-colored handle molded of CYMEL* melamine molding compound. Elegance and function are combined in the handle, balanced for easy, comfortable pouring. Harmonizing with the carafe's gold decoration, the molded-in color won't chip or wear off. In keeping with its function, CYMEL is exceptionally strong, resistant to heat and flame, and stays cool even when the carafe, made by Club Aluminum Products Company, is full of hot coffee.

*Trademark



1907 50 1957

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
32 Rockefeller Plaza, New York 20, N. Y.

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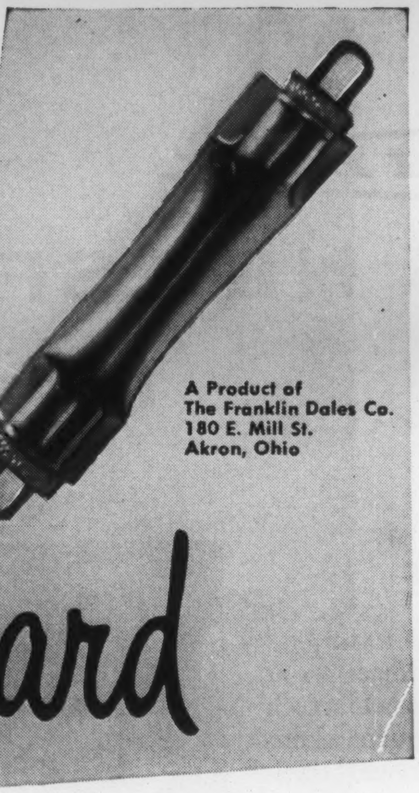
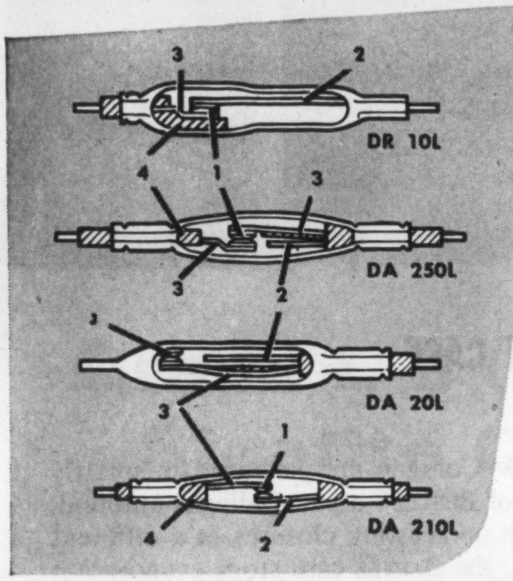
CYANAMID
Plastics
and Resins
Division

MATERIALS FOR TOMORROW

For more information, turn to Reader Service Card, Circle No. 497

How CHACE Thermostatic Bimetal Actuates the FRANKLIN DALES Temp-Guard


A Product of
The Franklin Dales Co.
180 E. Mill St.
Akron, Ohio



The Temp-Guard is an extremely compact, self-contained and sealed tubular type circuit breaker manufactured by The Franklin Dales Co. Numerous variations of standard models are used in applications such as electric motors, operating on-off cycling systems, detecting fire and activating alarms, protecting electrical appliances, controlling regulating systems, automatically making or breaking current to solenoids, transformers, etc. The accuracy and dependability of this interesting device hinge upon its actuating element of Chace Thermostatic Bimetal.

The photo shows a typical Temp-Guard actual size. Others vary from $1\frac{5}{16}''$ to $3\frac{3}{8}''$ in length. The sectional drawings show four representative types of circuits; the DR models have the thermostatic bimetal element in contact with the case; the DA models have element insulated from the case. The numeral "2" indicates that case does not carry current. Parts numbered in the drawings are:

1. **Contacts**
2. **Thermostatic Bimetal Element**
3. **Conductive Strip**
4. **Insulation**

In all examples, the bimetal element deflects in response to changes in ambient temperature or heating of the element due to overload, making or breaking the circuit.

Remember Chace when you design for temperature actuation or indication, or for protection of valuable equipment. Dependable Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal and many pages of engineering data.

IT BENDS WITH THE HEAT
W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service Card, Circle No. 542

What's new IN MATERIALS

Laminate, Aluminum Used in Panel Board

A panel board material consisting of a thermosetting plastics laminate sheet bonded to aluminum has been introduced by Panellit, Inc., 7401 N. Hamlin Ave., Skokie, Ill. It is recommended for control room panels including conventional large case and large case graphic panels, and miniature graphic panels.

According to the producer, the material permits reduction of time, effort and cost in revising panels in the field. Other advantages are resistance to scratching and denting, reduction of panel weight and good appearance.

Colored Oxide Finishes for Copper and Brass

A new oxide finish for coloring copper and its alloys has been developed by Enthone, Inc., 442 Elm St., New Haven, Conn. Called Enthocolor 220, the finishes are applied by immersing parts in a solution of an alkaline salt mixture for periods of 1 to 15 min at temperatures of 180 to 225 F. The process gives brown and shiny blue-black coatings on almost all copper alloys. Brown colors can be produced on copper and brasses; blue-black colors can be produced on brasses containing 20% or more of zinc. Unlike sulfide finishes, the new oxide finishes do not spot and can be severely deformed without cracking.

Glass Flake Paper for Electrical Parts

Transparent, colorless glass flakes averaging 0.25 x 0.25 x 0.0003 in. in size have been successfully converted into a paper-like product by T. D. Callinan

New Rokide* Coatings Resist Heat and Abrasion

Rokide spray coatings help solve many high temperature and wear problems

WITH the rapid increase in modern high temperature applications there has been a corresponding increase in demands for resistant materials. Norton ROKIDE spray coatings are meeting such demands with great success. These hard, adherent crystalline refractory oxides offer many important advantages. For example:

They are both thermally and electrically insulating . . . Their hardness, chemical inertness and stability in combustion temperatures provide high resistance to excessive heat, abrasion, erosion and corrosion. Their high melting points and low thermal conductivities reduce the temperatures of the underlying materials and permit higher operating temperatures.

ROKIDE Coatings vs. Stainless Steel

Analyses of Norton ROKIDE spray coatings and of stainless steel reveal interesting comparisons. While less dense than the bare steel, the ROKIDE coatings are very much harder, have considerably higher melting points and are very much lower in thermal conductivity and thermal expansion.

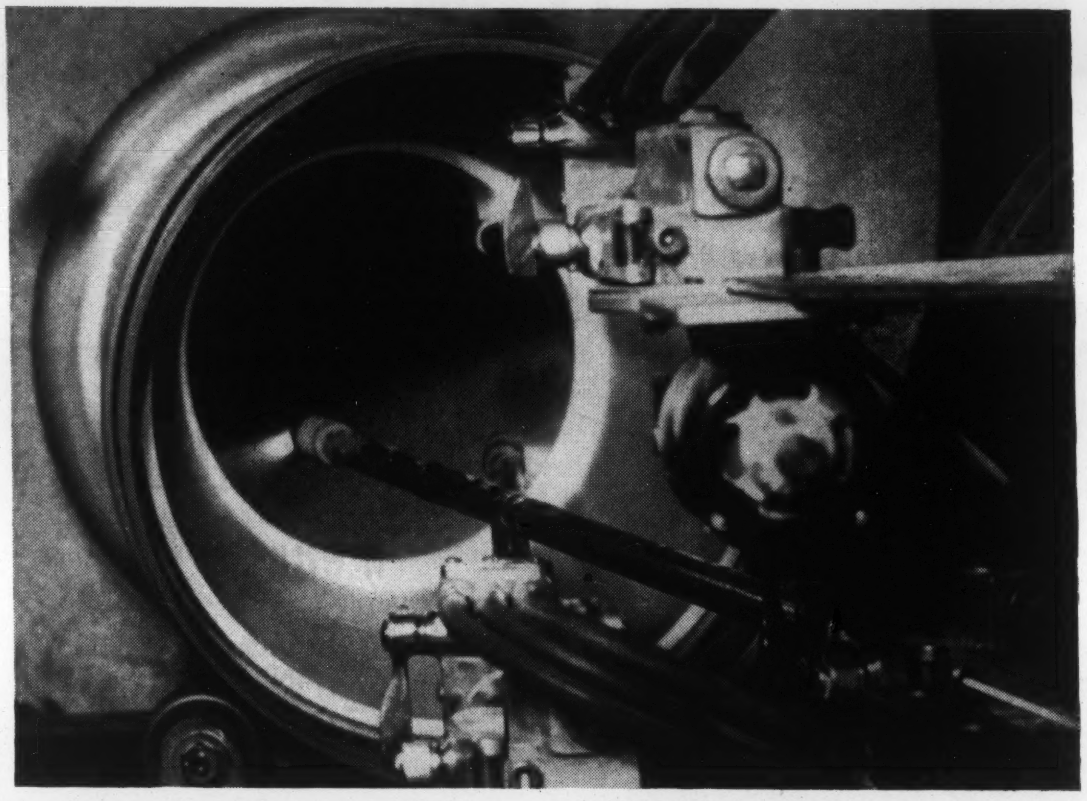
Proof

There are three Norton ROKIDE coatings: ROKIDE "A" aluminum oxide, ROKIDE "ZS" zirconium silicate and ROKIDE "Z" stabilized zirconia. These have been proved in such critical applications as reaction motors, as well as in AEC projects.

ROKIDE spray coatings are also helping to solve industrial problems involving: Electrical insulation • Thermal barriers • Electronic applications • Bearing surfaces • Erosion protection • Corrosion retardation • Chemical barriers • Positioning medium • Material up-grading • Altering emissivity and characteristics of surfaces • Surface catalytic activity • General wear resistance.

Although ROKIDE coatings are most commonly applied to metals they are effective on other materials, such as ceramics and certain plastics. Thicknesses of the coatings generally range from .005″ to .05″.

For more detailed information on ROKIDE coatings, write to: **NORTON COMPANY,** ***New Products Department,*** Worcester 6, Mass.



ROKIDE Spray Coatings are applied in a molten state by means of a metalizing type spray gun⁎. The oxide is fed into the gun in rod form at a carefully controlled rate. The coatings can be applied to parts of any size and to all shapes accessible to the spray gun equipment. Multiple gun set-up shown in illustration.

NORTON

NEW PRODUCTS

Making better products... to make your products better

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

Facilities for applying ROKIDE coatings available at:
NORTON COMPANY
Worcester, Massachusetts
and
2555 Lafayette Street, Santa Clara, California

⁎ Manufactured by Metallizing Company of America, Chicago 32, Ill.

For more information, turn to Reader Service Card, Circle No. 468

Base your production plans on
WYCKOFF
Quality Control
STEELS
COLD FINISHED STEEL
Controlled
CARBON and ALLOY

For you . . .
Quality Control
means

- FASTER MACHINING
- LONGER TOOL LIFE
- ACCURATE SIZE
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MORE PROFIT TO YOU!

Wyckoff
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•
CARBON ALLOY LEADED

WYCKOFF STEEL COMPANY

General Offices: Gateway Center, Pittsburgh 30, Pa.
Branch Offices in Principal Cities
Works: Ambridge, Pa. • Chicago, Ill. • Newark, N. J. • Putnam, Conn.

For more information, turn to Reader Service Card, Circle No. 407

PROPERTIES OF IMPREGNATED GLASS PAPER

Properties	Impregnants		
	Alkyd	Phenolic	Silicone
Resin Content, %	39	40	55
Density, gm/cu cm	1.14	1.16	1.74
Ten Str, psi	900	1800	700
Water Absorp, %	0.4	1.5	0.0
Dielec Const (10,000 cps)	2.30	1.69	1.80
Power Factor (10,000 cps)	1.69	0.25	0.20
Dielec Str, v/mil	100	120	105
Volume Res, ohm-cm	10^{13}	10^{13}	10^{13}

and R. T. Lucas, of the U. S. Naval Research Laboratory. (See also article on glass fiber paper, M&M, Dec '55, p 99.) The two researchers seem to think that the physical and electrical characteristics of glass flake products tested by them justify pilot and mill trials of glass flake paper.

Details of glass flake preparation and a discussion of the properties of glass flake paper are contained in the Oct '56 issue of the *Journal of the Electrochemical Society*.

Making glass paper

The glass flake paper used in the evaluation was made on a laboratory scale by blending glass flakes in a water and acid solution to a fine and dispersed pulp. The pulp was then placed in a standard sheet mold where a uniform, porous, brittle and transparent sheet approximately 10 mils thick was obtained.

The glass flakes used in the manufacture of the paper-like product were a borosilicate glass, type E (10 boron oxide, 54 silicon dioxide, 16 calcium oxide, 16 aluminum oxide and 5% sodium and potassium oxide) that softens at 1544 F. The flakes were made by rapidly cooling a thin film of molten glass that shattered into fine particles.

The transparent sheet made of the glass flakes had a glass content of 100% and a thickness of 0.010 in. Tensile strength of this

. . . better molded parts because of

1200 years of tool and die experience

This composite picture represents 100 Richardson tool and die men with a combined experience of 12 centuries.

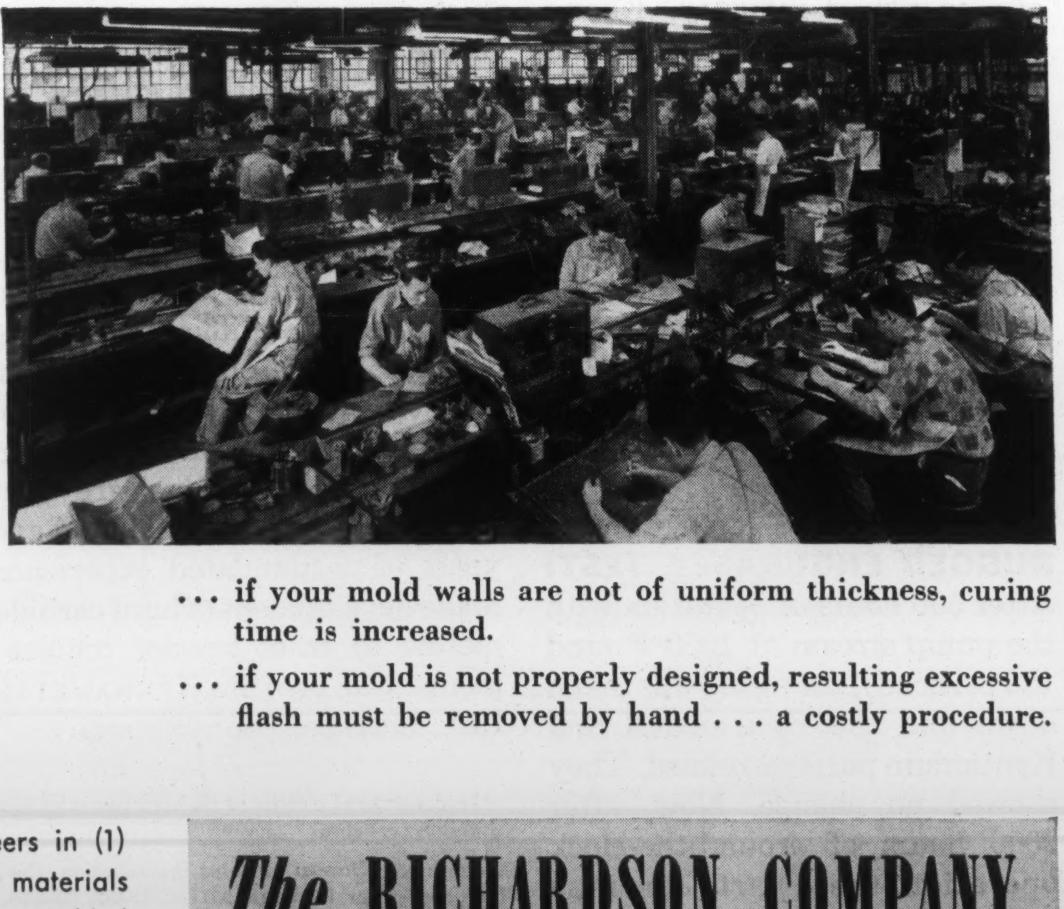
At least 50% of getting a good molded part depends on the quality of your mold.

The composite photo shown to the left represents the broad and varied experience needed for the design and production of quality molds to close tolerances . . . it represents 100 Richardson men with more than 1200 years combined experience in the design and production of tools and dies for the production of molded plastic parts.

The men who make Richardson molds know and respect the many "ifs" encountered in the design and production of quality molds. They know that . . .

. . . if your mold isn't correctly designed, the resulting parts will not be according to specifications.

. . . if your mold is not properly designed, the parts cannot be ejected quickly, production speed will be reduced, and unit cost increased.



The Richardson mold and die shop at Melrose Park, Illinois, is one of the largest in the plastics industry.

. . . if your mold walls are not of uniform thickness, curing time is increased.

. . . if your mold is not properly designed, resulting excessive flash must be removed by hand . . . a costly procedure.

Richardson
MOLDED PLASTICS

Richardson engineers can assist your engineers in (1) redesigning parts for conversion from other materials to molded plastics, and (2) designing to improve molded parts now in production.

For additional information and a copy of the newly published catalog, "Richardson Molded Plastics," write or phone, today . . . Chicago number, MAnsfield 6-8900.

The RICHARDSON COMPANY

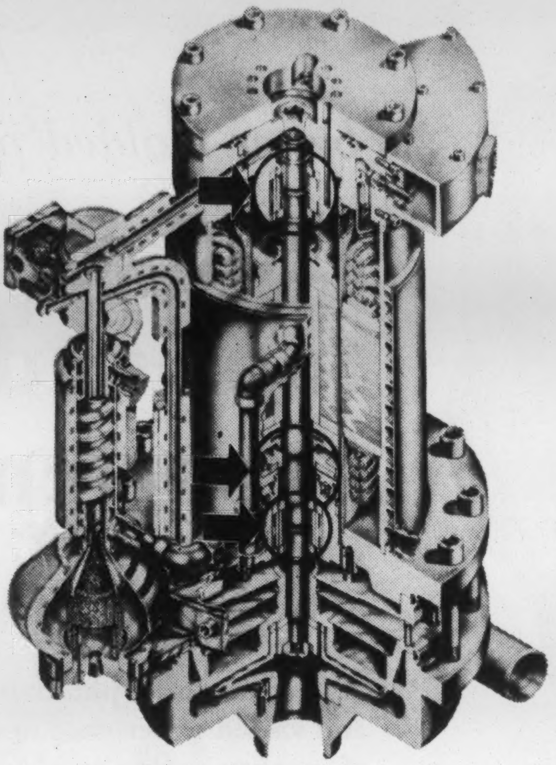
MOLDED AND LAMINATED PLASTICS

. . . better plastics for better parts

Dept. 17, 2782 Lake St., Melrose Park, Illinois

For more information, turn to Reader Service Card, Circle No. 472

Both KENNAMETAL* and KENTANIUM* in Westinghouse liquid metal pump



Bearings and thrust runners operate perfectly after 2000 hours handling sodium, NaK and other metals at 1050°F and above

Cut-away view of Westinghouse pump to handle liquid sodium, NaK or other metals at temperatures up to 1500°F. Circles show bearings and thrust runners of Kennametal and Kentanium, which meet the most rigid specifications of tolerances and quality of material to provide continuous, 100% leak-proof pumping operation for extended periods.

Kennametal and Kentanium are sharing in one of the engineering advancements of the year . . . the Westinghouse centrifugal liquid metal pump designed for the atomic power industry. Kennametal grade K9** and Kentanium K138A** were selected for the vital bearing and thrust runner parts which are lubricated by liquid metal with a film much thinner than oil lubricants. Surfaces must not corrode and must be highly wear resistant to maintain leak-proof seals . . . rugged requirements which Kennametal and Kentanium have met under gruelling tests.

RUGGED ENDURANCE TEST: After 500 hours of operation with the pump stream at 1050°F (and 120 psi head), the pump was taken down and the Kennametal and Kentanium parts examined. They showed no change. Now, after 2000 hours of around-the-clock operation, these parts continue operation in apparent perfect condition. Larger Westinghouse pumps now being built to handle sodium and NaK at 4000 gpm and 1500°F at 250 psi pump head include similar parts of Kennametal and Kentanium.

These applications suggest the use of Kennametal or Kentanium wherever two surfaces rub together or are forced together . . . especially under severe conditions as encountered in handling liquid metals or other difficult-to-handle materials. Such applications might include valve seats, rings, bushings, sleeves on shafts, etc. Kennametal engineers are prepared to assist you. They have years of accumulated experience in the development of hard carbide metals to meet special requirements. Call or write KENNAMETAL INC., Latrobe, Pennsylvania.

*Trademarks of a series of sintered tungsten and titanium carbides.

**Approved, Bureau of Ships Specification, Carbide Stocks for Bearings, MIL-C-18482, 20/4/55.

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material was 86 psi and density was 0.75 gm per cu cm. The material had a Mullen burst number of 1 and an Elmendorf tear strength of 20 lb.

Resin impregnation

Although the glass flake product was self-supporting, it was difficult to handle without a binder. Thus, three resins were studied as impregnants for the glass material: an alkyd varnish (GE 1202), a phenolic enamel used in motor insulation (Du Pont 8995 Formvar), and a silicone (Dow Corning 993). The glass paper was readily saturated and, on drying, yielded mechanically strong, water resistant, transparent dielectric sheets.

The impregnated papers were air dried for 16 hr, then subjected to a temperature of 250 F for 8 hr. The silicone-impregnated paper was heated 16 hr longer than the alkyd and phenolic-impregnated papers.

All impregnated papers had substantially greater tensile strength, density, dielectric constant and water resistance compared to the nonimpregnated papers. Physical, mechanical and electrical properties of the impregnated glass papers are given on page 256.

Modified Butyl May Be Used in Tires

Several hundred automobile and truck tires made of chemically modified butyl rubber are presently undergoing exhaustive road tests. The modified butyl rubber has less heat build-up than previous butyls and is said to have resilience and strength properties approximately double those of unmodified butyl.

The new rubber is made possible by a chemical modifier, called Elastopar, now being produced in semicommercial quantities by Monsanto Chemical Co. It is added to butyl rubber in the course of conventional processing

Grandmother-

YOUR PATCHING DAYS ARE OVER...

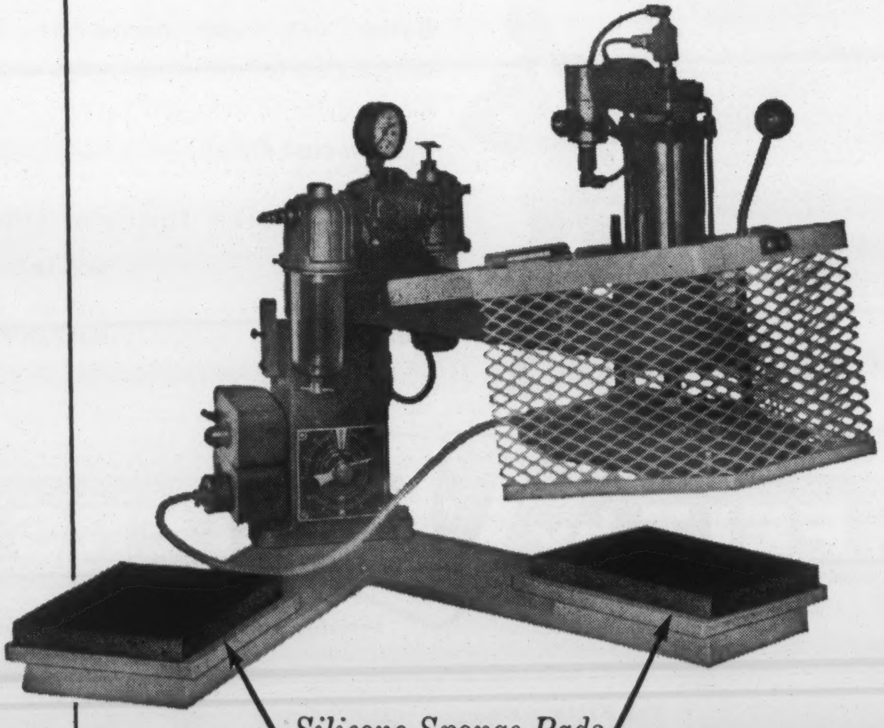
Roth developed silicone sponge rubber pads solved heat and pressure adhesion problems of commercial patcher

High heat and high pressure are required to melt the adhesive and to make a lasting seal in commercial patches used in the overall and uniform supply industry. An automatic patching machine had been developed for this purpose but production was held up as patches were not getting the proper adhesion . . . particularly over seams and under buttons.

ROTH RUBBER Technical Knowledge and Experience developed a silicone sponge that would withstand the 400°F. temperature required and the 80 pounds per square inch pressure. Not only does a pad of this Roth silicone sponge withstand this pressure and temperature but it retains its resiliency over thousands of patching cycles.

The American Heat Seal Patching Machine, manufactured by American Heat-Seal Inc., Chicago, provides complete safety for the operator and automatically controls time, temperature and pressure for applying "Stay On" patching material. For faster output, two pads of Roth developed silicone sponge are used and the operating arm of the machine is swung from one pad to the other.

IF YOURS IS A PROBLEM IN RUBBER...LET ROTH'S EXPERIENCE WORK FOR YOU



Silicone Sponge Pads

Write for technical data on Roth developed silicone sponge and molded silicone rubber parts

ROTH RUBBER COMPANY Division of Vapor Heating Corporation
1860 South 54th Avenue • Chicago 50

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Felters has combined a variety of fibers — wool, rayon, cotton, dynel, nylon and dacron — with a resin (thermoplastic) binder. Result: a felt-like fabric with a tremendous range of fiber combinations — using different diameters, lengths and gravities.

The thermoplastic binder has two big advantages: (1) AllFab will hold any embossed pattern, actually gives dimension to a design; and (2) it is possible to electronic "stitch" or heat seal, eliminating sewing. These features open a new realm of uses as low-cost filler and backing for plastics and upholstery, and for creating new packages and box designs.

Better yet, you name it! Felters will be glad to furnish samples and technical advice to help you save money with this low-cost AllFab.

One of the NEW family of felts . . .

MiraFelt®	MX-101
Dynel-Mat	AllFab
Unisorb®	Cut Felt Parts

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Manufacturers of Felt and Felt Products

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Address...

City..............................Zone....State...................

FE6-13

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steps and is said to provide all of the benefits of a long heat treatment during a normal mixing cycle. It also gives easier mixing and smoother, faster extruding and calendering.

Improved Hot Strength in 302 and 316 Steels

For some time alloy producers and jet engine manufacturers have exhibited interest in the possibility of using leaner alloys for aircraft production. One approach has been to add titanium and boron to 302 and 316 stainless steels in order to improve their hot strength.

J. Salvaggi and L. A. Yerkovich, of Cornell Aeronautic Laboratory, have evaluated the 100-hr rupture life at 1500 F of a substantial number of such compositions prepared as 15-lb heats and rolled to approximately 0.050-in. sheet. Although the nominal 100-hr rupture strength at 1500 F is in the 5000-9000 psi range for the

Fractionating tower—This massive tower was fabricated in a single piece from 1-in. thick steel plate. Believed to be the largest ever built, the tower is 21 stories high, weighs 410,000 lb, and has an 11-ft, 8-in. dia. It was built by Delta Tank Mfg. Co. for Esso Standard Oil Co.

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Set Screw & Mfg. Co. News

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Issue No. 4 **Bartlett, Illinois** **EXTRA!**

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. . . Another $35,000 . . . and Another SAVED the ENTIRE COST OF SET SCREWS

These and similar *savings* are being accomplished by using special type Setko Set Screws to overcome costly difficulties such as vibration . . . close-precision setting . . . fastener-failures . . . floor loss . . . or to obtain production set-up (increases up to 10 times) and screw inventory reduction, etc. Let us show you how we can Save YOUR Plant Some Real Money in 1957 with Set Screws designed to solve *your* particular problems. Use coupon below to get Test Samples.

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In the first year of its operation, a number of manufacturers report that savings from Hopper-feeding of various type set screws have already paid back cost of installing special mechanism. Because it requires 1/5 to 1/10 former time, eliminates cross-threading, rejects misfits, etc. Use on metal or plastic products. Let us send you list of users and arrange for special Hopper-Feeding Demonstration at our plant. Check Coupon Below.

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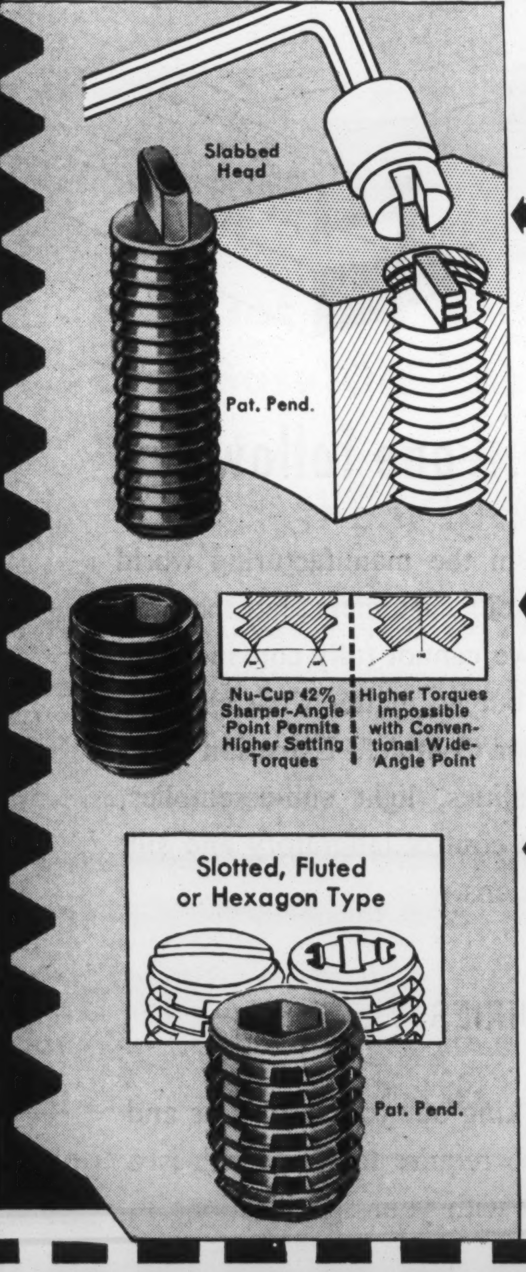
Check "Jewel Case Bulletin" on Coupon.

Such SAVINGS were made possible by New Type SET SCREWS like these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Pat. Pend.
Nu-Cup 42% Sharper-Angle Point Permits Higher Setting Torques
Higher Torques Impossible with Conventional Wide-Angle Point
Slotted, Fluted or Hexagon Type
Pat. Pend.

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For use where "flush" insertion is desired; made with an undersized slab; can be set to same holding power as equivalent size socket screw, at 25 to 50% less cost.

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☐ Test Samples (To meet our problem described on separate sheet.)
☐ "Jewel Case" Bulletin
☐ Set Screw Catalog

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MY NAME.. POSITION............................
COMPANY..
ADDRESS.................................... CITY......................... STATE.....................

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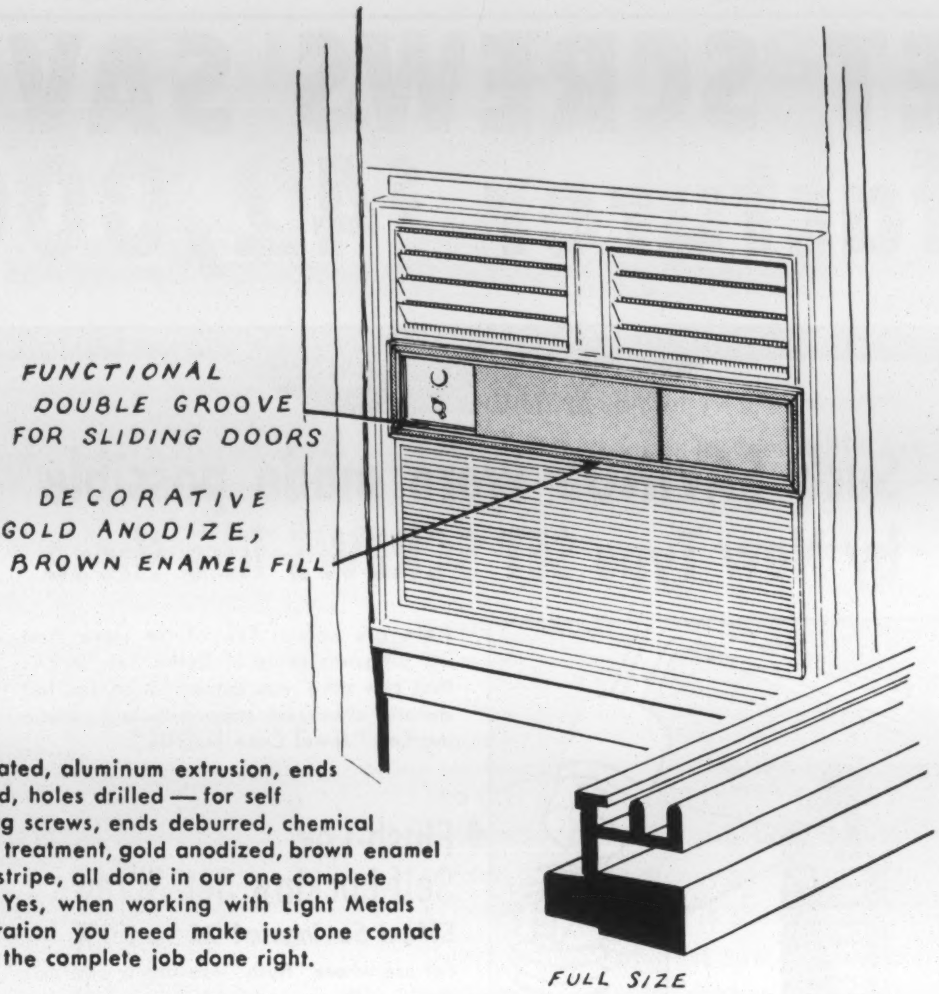
FOR THE MANUFACTURERS WHO CAN AFFORD ONLY THE MOST ECONOMICAL TRIM PARTS



FUNCTIONAL DOUBLE GROOVE FOR SLIDING DOORS
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FULL SIZE

Fabricated, aluminum extrusion, ends mitered, holes drilled — for self tapping screws, ends deburred, chemical bright treatment, gold anodized, brown enamel paint stripe, all done in our one complete plant. Yes, when working with Light Metals Corporation you need make just one contact to get the complete job done right.

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conventional steels, values of 18,000-20,000 psi were obtained for several of the titanium and boron modifications of these alloys. A number of alloys demonstrated similar gains at 1350 F. Other conclusions resulting from this work originally presented at the 38th annual convention of the American Society for Metals, are:

1. Titanium, boron and carbon are all capable of improving the 100-hr, 1500 F rupture strength of type 302 and 316 stainless steels heat treated in the range of 2100 to 2300 F. Rupture ductility remains good and in most cases is better than that obtained for base compositions solution treated at these temperatures.

2. For the range of compositions studied, maximum high temperature strengths increase as carbon levels are raised. The largest strength increment occurs between 0.07 and 0.15% carbon. Rupture ductility is relatively unaffected, particularly in alloys containing combined titanium and boron additions.

3. High temperature strength of the modified type 316 stainless steels is superior to that of the modified type 302 steels under similar conditions of heat treatment and at similar titanium, boron and carbon levels.

4. When titanium and boron are added jointly to type 302 and 316 stainless steels, peak 100-hr rupture stresses occur at progressively lower titanium contents as boron increases.

5. Maximum rupture strengths of stainless steels containing titanium and boron as single additions and also in combination are greatly improved, in most cases, by utilizing higher heat treating temperatures. These gains are generally accompanied by a decrease in rupture ductility. This decrease in ductility is not as pronounced for the boron-bearing steels as it is for the steels containing titanium alone.

(more What's New on p 268)

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The Zinc that originally put Zinc-Base Die-Castings on a High Level ... and has kept them high!

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Cementable Tapes for Insulation, Linings

A line of cementable glass-reinforced and unsupported Teflon tapes has been announced by Continental Diamond Fibre Corp., Newark, Del. Both the reinforced and unsupported tapes can be bonded with ordinary adhesives to metal, plastics, glass, wood, ceramics and rubber. They are produced in widths from ¼ in. to 12 in. and in thicknesses from 0.002 to 0.060 in.

The tapes may be used as coil and motor winding insulation, noncorrosive linings, facings for conveyor belts, and duct linings.

Nylon Fabric Used in Inflated Warehouse

A pneumatically supported warehouse made of paper-thin, vinyl-coated nylon fabric, has been developed by U. S. Rubber Co. The building, 80 ft long, 40 ft wide and 20 ft high, contains more than 64,000 cu ft of storage space and can be erected by three men in 1 hr.

It is erected with air from a compressor. The compressor maintains a constant stream of low pressure air which enables the building to keep its shape and taut appearance.

The vinyl-coated nylon material, called Fiberthin, weighs 8 oz per sq yd and is resistant to scuffing, sunlight, oils, gasoline, most acids, alkalis and salt water.

Portable warehouse *is large enough to hold two million pounds of packaged goods.*

PRICES AND SUPPLY

The Outlook

by Herman B. Director, *Consultant, Washington, D.C.*

Steel production to continue at a high rate

Steel production has not dropped below 95% of capacity since the work stoppages last summer. This can be attributed to several factors: 1) even when the automotive industry sells less than six million cars, as it did in 1956, it still consumes almost 14 million tons of steel; 2) production of heavy products, such as structural and plate, now accounts for over 16% of total mill shipments, compared to 14% in 1955; and 3) a careful study of what actually happens to the 20%, or 18 million tons, of steel shipped to warehouses shows that, contrary to AISI figures, the construction industry consumes not 12% of steel shipments but closer to 15%. Similarly, the machinery industries consume about 16%, rather than AISI estimates of 9%.

Steel industry expansion is directed toward heavy products; of the $2 billion which the steel industry has indicated it is prepared to spend on expansion, almost $800 million will be used for further expansion of structural and plate capacity. This increase in capacity should be ready in sufficient time to meet the expanding needs of highways, freight cars and ships. In fact, we are quickly catching up with the freight car backlog. The highway program is slow in expanding due to legal and financial problems, but the shipbuilding program, which will require a very large portion of its heavy steels sometime beginning in late 1958 and on through 1960, should have its needs met without much difficulty.

Pressure on Government to purchase copper

Copper prices continue to fall. However, U.S. producers are reluctant to drop the price in the face of Chilean dependence on U.S. markets. This accounts for the recent two-stage drop, i.e., from 36¢ to 34¢ and then to 32¢ per lb. As soon as the market dropped to 32¢ per lb, custom smelters lowered their price to 31¢. This foreshadows a further drop in price to 31¢ per lb by U.S. producers. When the producer price reaches 31¢ per lb, there will be increasing pressures for the U.S. Government to bolster the market. This will be accomplished in two ways: 1) domestic producers with Government contracts to deliver copper to the Government at 31¢ per lb or higher will deliver to the Government; 2) the Commodity Credit Corp. will be under strong pressure to put copper on its list of materials desired for barter.

Pressure on the Government to go into the copper market is, in fact, beginning to show up in some unusual places. The *Waste Trade Journal*, in an editorial on Jan 19, makes a case for the Government to enter the market and begin to buy copper which is in excess of demand. We wonder whether this plea for the purchase of copper on the part of the secondary industry is not designed to set the stage for a program which will urge the Government to buy secondary ferrous materials in the event they too become surplus. We are mindful of the 1954 situation when, in the face of declining prices for scrap iron and steel, the secondary industry urged the Government unsuccessfully to stockpile metal scrap in order to bolster the scrap market.

Attempt to cut mineral subsidy fails

The House of Representatives cut $30 million from its appropriation for the purchase of asbestos, columbium-tantalum and fluorspar. The Senate, in acting on the same appropriation bill, promptly restored these funds for a continuation of mineral subsidies. In support of continuation, Felix Wormser, Assistant Secretary for Mineral Resources, Dept. of the Interior, said he favors continuation of the subsidy until such time as the Government acts in favor of increased tariffs on zinc, lead and other materials in order to protect domestic producers. He stated categorically that these materials were not needed by the Government for its stockpile program and emphasized the fact that until tariff protection is afforded, he must continue to support a subsidy program as a less desirable alternative.

With regard to these materials, we would like to point out that there are abundant supplies of columbium-tantalum; all domestic tungsten goes to the Government and commercial needs are met from foreign sources; asbestos has more than met its match in fiberglass for strategic applications; and there is an abundant supply of fluorspar. The net result, of course, is that domestic consumers, in addition to paying their share of the subsidized price via the tax route, must also pay higher prices for the materials they consume.

Price cutting in aluminum extrusions

All producers of extruded aluminum shapes used largely in storm windows, doors and decorative hardware are engaged in price cutting competition. This struggle is attributed to the fact that after an extremely rapid growth following the Korean War, the industry has 100 companies competing for business at a time when growth of residential housing is at a low point. As a result, extrusions are available in the market at 10¢ per lb less than the 60¢ list price.

Zirconium comes of age

Zirconium production is now reaching a level of commercial availability. In addition to the widely publicized applications of zirconium for atomic energy, zirconium-containing alloys are being used in such nonstrategic applications as flatware and dinnerware on board ships.

Shortage of pure tantalum and columbium

The demand for pure tantalum, used in electronics equipment, exceeds the supply. This situation will exist for the next two years, even though the major producer of tantalum is expanding his plant and four other companies are toying with the idea.

The situation with regard to pure columbium is similar. Demand for pure columbium for heat exchangers and other process equipment exceeds the supply. Furthermore, expansion of facilities for the production of pure columbium appears to be lagging behind expansion of facilities for pure tantalum.

Reinforced plastics consumption continues to grow

Reinforced plastics consumption, which increased in 1956 to 140 million pounds—30% over the previous year's figure—will probably increase again in 1957. However, the increase will not be so spectacular.

Production of low pressure polyethylene up

In 1957 high density (low pressure) polyethylene capacity should increase to about 100-150 million pounds. This material is far superior to low density (high pressure) materials for such applications as wire and cable insulation. In some cases it will supersede conventional polyethylene as a cable covering, and it might even replace conventional polyethylene as a jacketing material over lead.

Selenium, bismuth prices to drift lower

Demand for selenium, mercury, bismuth, platinum and rare earths, though at a reasonably high level, will not put a squeeze on the supply. Export restrictions on these materials have been progressively relaxed and are, in effect, restrictions in name only. We expect the prices of these materials to continue to drift downward. In the case of mercury we expect the price to drift down to the Government purchase price of $225 per flask, as compared to the current market price of $255.

Nickel supplies to increase somewhat

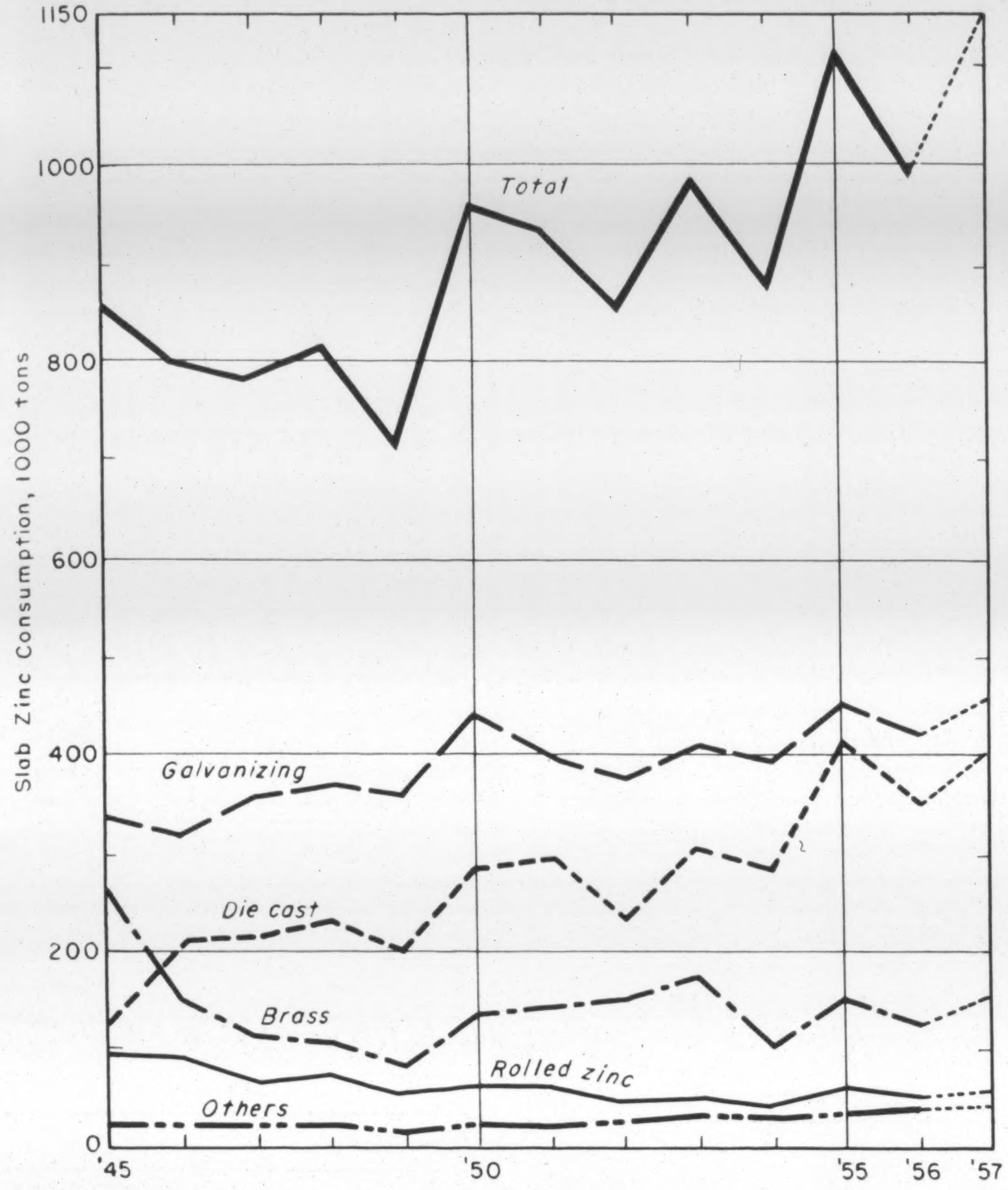
If the defense program does not require more nickel than it is currently using, additional supplies should become available to civilian consumers during the second quarter. Recent arrangements concluded by the Government will provide market-price nickel to small consumers who use 100 lb of nickel per month. Larger consumers will benefit from increased supplies of high price nickel which the Government has arranged to divert from U.S. account to industrial consumers. The current outlook, however, is that all consumers will still be willing to build inventories now virtually nonexistent, at prices above the 74¢ base price for nickel.

Tin price remains firm

The International Tin Council, which controls supplies and prices of tin, is expected to turn down Bolivian proposals to increase the price. The Tin Council purchases tin in the event price drops below a fixed level. The U.S. buys about 50% of the world's tin and, though not a member of the Tin Council, has maintained a very close liaison with this organization. Members of the Council are shying away from the Bolivian proposal unless it can be demonstrated to the satisfaction of the United States that price increases are actually required.

On the other side of the picture, work stoppages in Malaya have prevented tin prices from decreasing. It was originally anticipated that tin ores normally coming to the Texas City tin smelter would enter world markets, increase the supply and result in reduced tin prices.

Insofar as smelting facilities are concerned, there has been a fairly easy and successful transition from use of the Texas City facilities to other facilities available in Western Europe, including Holland, Germany and the United Kingdom. The extremely high production rate of tin plate here in this country should keep tin prices firm.



Consumption *of slab zinc by industry, from 1954 to 1957.*

Production and Use of Zinc Expected To Be Highest in '57

Domestic smelter production of slab zinc during 1956 reached an all-time high of 1,062,955 tons. This represents a 3% increase over the industry's previous high of 1,031,018 tons registered in 1955. And, although consumption of zinc in 1956 was slightly below consumption in 1955 — 994,000 tons compared with 1,119,812 tons, indications are that 1957 will see all records broken.

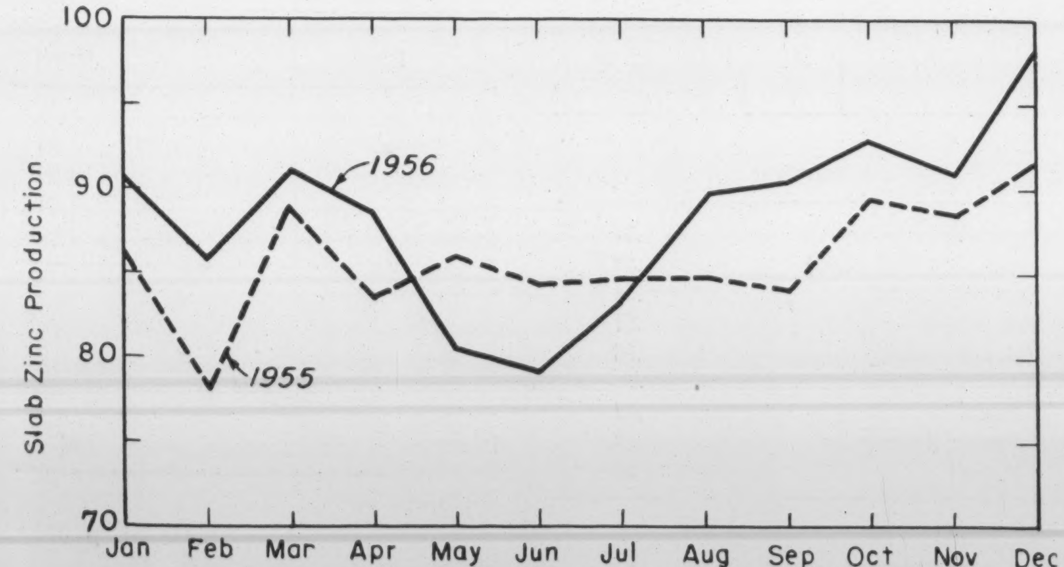
According to John L. Kimberley, executive vice president of the American Zinc Institute, three factors are responsible for the zinc industry's confidence: 1) the growing market for zinc in die-casting, 2) its expanding use in galvanizing of steel, and 3) the integral place it holds in brass manufacture, rubber and paint formulation.

The average 1957 automobile carries 65 lb of zinc, with die castings used for head and tail light assemblies, and instrument panel assemblies, as well as such functional parts as carburetors, windshield wiper motors, door handles, window cranks, etc. Last year 60 lb of zinc were used per car.

Mr. Kimberley points out that the steel industry is continually expanding its use of continuous sheet galvanizing lines. At present more than 75% of the galvanized sheet being produced comes from some 34 of these lines now operating. The figure is expected to increase to 90% in the near future.

The AZI is currently winding up an important stage of a major research program aimed at improving the use of zinc anodes for the cathodic protection of a wide variety of structures, including piers, pipelines, ship hulls, and gas distribution systems and tanks. Success in this and other

(continued on p 278)



(Both charts based on American Zinc Institute figures.)

Comparison *of zinc production (1000 tons) in the last two years.*

SLAB ZINC CONSUMPTION, TONS[a]

End Use	1955	1956
Galvanizing	451,000	429,000
Brass Products	146,000	121,000
Zinc-Base Alloys	431,000	360,000
Rolled Zinc	52,000	47,000
Zinc Oxide and Others	40,000	37,000

[a] Based on American Zinc Institute figures.

Prices of Materials

Changes since last month are bold faced.

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in \$/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.65	.44-.54
Butadiene-Styrene	.16-.30	.26-.32
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	.47-1	.70-.92
Natural	**.33**[b]	—

[a] Less than carload quantities.
[b] Average spot price for month of Jan.

GLASS FOR REINFORCED PLASTICS

Fabric (\$/yd, 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	1.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a,b]	.52-.72
Surfacing (\$/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

[a] Price includes binder or finish.
[b] Price varies with binder.
[c] 0.010-0.020 in. thick.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.40	.17-.34
Polyester	**.42**	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a] 60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.50-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
PTFCE	**7-8**	15-23	**18-22**	**14-20**	**20-22.50**	**16-20**
PTFE	4.50-7.45	14.30-11	13		13	
Nylon	1.35-2.30	—	3		3	
Polyethylene	.37-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.27-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in \$/lb except where indicated

ALUMINUM

Pig (99-99.9%)	.25-.27
Ingot (99-99.9%)	.27-.29
Foil (5-0.5 mil)	.55-.77
Alloy Ingot (13, 43, A132, 214)	.29-.32
Sheet (1100, 3003; 3-.03 in.)[a]	.40-.45
Plate (1100, 3003, 5050, 3004, 5052)[a]	.40-.43

[a] Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	**.48**	**.50**	**.51**
Seamless Tubing	**.50**	**.53**	**.54**
Rod (not f.c.)	**.47**	**.50**	**.51**
Wire	**.48**	**.51**	**.52**

COPPER

Ingot (elec)	**.32**
Sheet, Strip (hot rolled)	**.54**
Seamless Tubing	**.54**
Rod, Drawn	**.51**
Rod, Free Cutting	**.60**
Wire	
Round	**.37**
Square, Rectangular	**.41**
Magnet	**.45**

LEAD

Common Grade	.16

MAGNESIUM

Pig (98.8%)	.36
Ingot (98.8%)	.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a] Delivered price.

NICKEL

Form	"F"	"A"	Monel
Ingot	.75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

[a] Delivered price.

TIN

Primary[a]	**.98**

[a] Delivered price.

(continued on p 274)

NOTHING *can* *equal Stainless Steel*

in its unique combination of properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. For a reliable source of supply, United States Steel offers you the widest range of types, finishes and sizes.

UNITED STATES STEEL CORPORATION, PITTSBURGH
AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

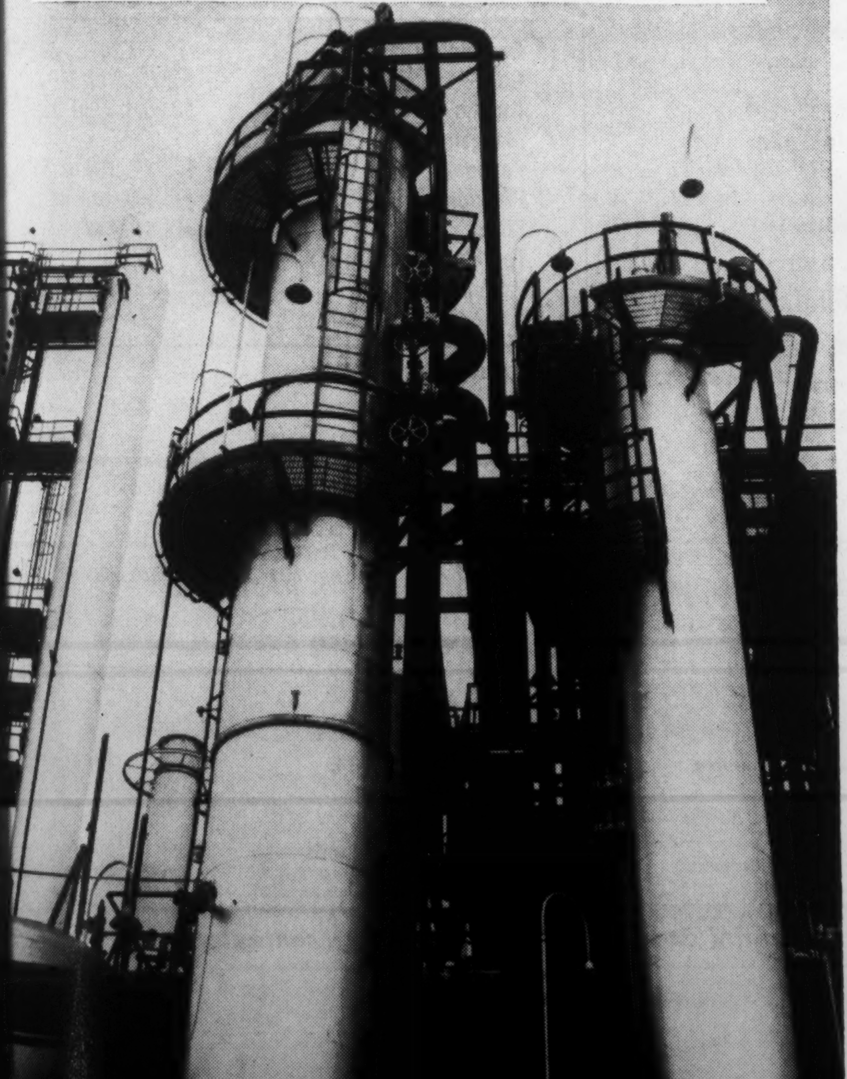
USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

UNITED STATES STEEL

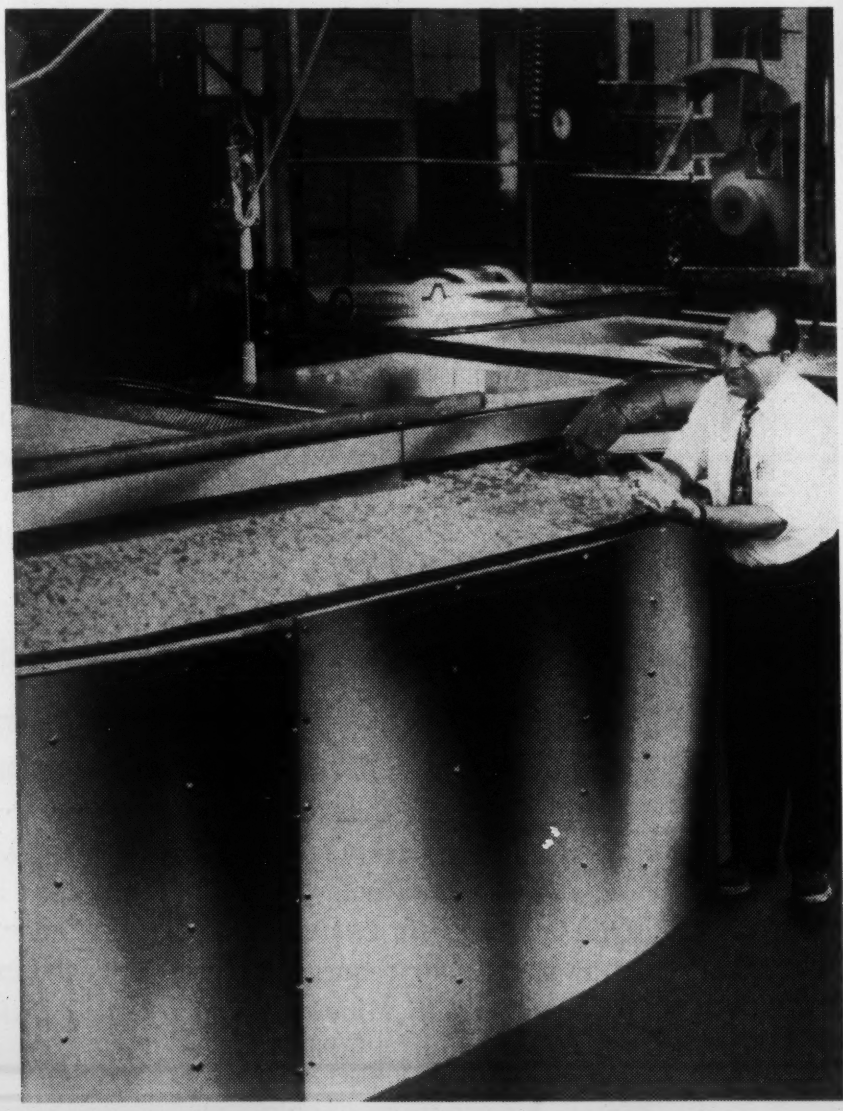
For Corrosion Resistance

This petrochemical extract fractionator was originally made from carbon steel . . . but corrosion ate through the plates and put it out of service in *just two months*. They lined the tower with type 316 Stainless Steel. When examined, the tower had been in service 21 months, and the Stainless was still in good condition.



For Sanitation

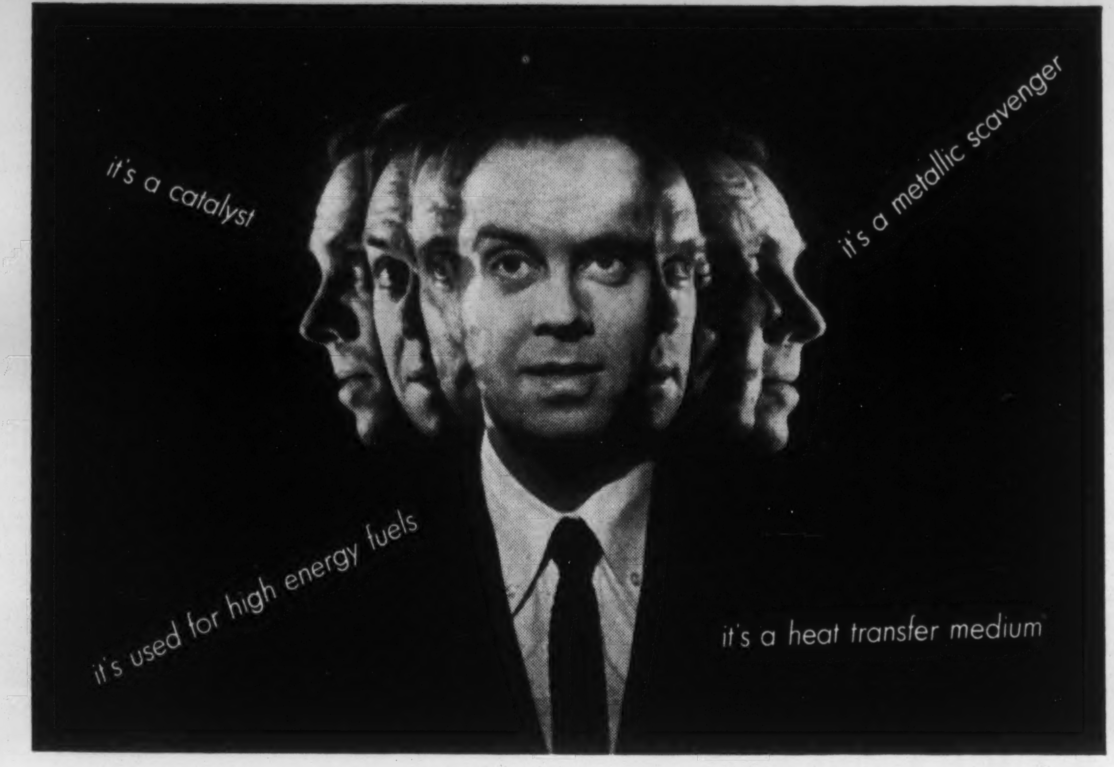
Food juices are incredibly corrosive, so some restaurants have a lot of trouble in their cold storage rooms because the racks corrode and harbor bacteria. Eastern Steel Rack Company makes racks from Stainless Steel. They are easy to keep clean; and, for all practical purposes, they *never* wear out.



For Cleanliness

Hawthorne Paper Company, Kalamazoo, Mich., goes to extraordinary lengths to guard against color contamination. Old wooden tanks were thrown out and replaced with Stainless Steel. According to the men at Hawthorne, the Stainless has absolutely no contaminating effect, and it's easy to fabricate.

For more information, turn to Reader Service Card, Circle No. 401


it's a catalyst
it's a metallic scavenger
it's used for high energy fuels
it's a heat transfer medium

WHAT IS LITHIUM?

The fact is, lithium metal is all of these things . . . *and many more.*

It's now being used as a catalyst for precise control in polymerization and organic chemical reductions. It's potentially the most effective and efficient medium for any high temperature exchange system . . . with a molten range of 179°C.to 1317°C.and a very high specific heat. Because it reacts with so many gases to form stable compounds, and absorbs such large volumes of gas, lithium is an ideal metallic scavenger, economically deoxidizing, desulfurizing, and degasifying metals, while increasing conductivity.

At the same time an exciting new chapter of lithium is being written in the atomic energy field. Having two isotopes with almost opposite characteristics, lithium becomes potentially useful in nuclear applications. And with its derivatives, lithium also shows great promise in the production of high energy fuels.

These are just a few of the better known applications for lithium metal . . . all relatively new. That's why chances are that you, too, will be using this lightest of all metals in the next five years . . . in research, in production, or in the manufacture of your product. Foote's vast amount of technical data, backing up its production of 99.8% lithium metal is ready to help you get there faster—maybe first. Our Data Bulletin *Lithium Metal* is a good start. Your copy is awaiting your request at the Technical Literature Department, Foote Mineral Company, 408 Eighteen West Chelten Building, Philadelphia 44, Pa.

Foote
MINERAL COMPANY

SALES OFFICE: *Electromanganese Division, Knoxville, Tennessee*
RESEARCH LABORATORIES: *Berwyn, Pennsylvania*
PLANTS: *Cold River, N. H.; Exton, Pa.; Kings Mountain, N. C.; Knoxville, Tenn.; Sunbright, Va.*

ELECTROLYTIC MANGANESE METAL • WELDING GRADE FERRO ALLOYS • STEEL ADDITIVES • COMMERCIAL MINERALS AND OXIDES • ZIRCONIUM & TITANIUM (IODIDE PROCESS) • LITHIUM METAL CHEMICALS AND MINERALS • STRONTIUM CHEMICALS

For more information, turn to Reader Service Card, Circle No. 593

PRICES AND SUPPLY

TITANIUM

Sponge (99.3+%)	2.50-2.75
Bars, Rod	7.10-7.35
Plate	9.25-11.25
Sheet, Strip	11.40-12.10
Wire	8.50-9.00

ZINC

Primary[a]	.13-.14[c]
Die Casting Alloys[b]	.18-.19[c]
Sheet	.24
Ribbon	.22

[a]Prime Western—Special High Grade.
[b]Alloys 2, 3, 5. [c]Delivered price.

METAL POWDERS

Aluminum [a,b]	.36
Brass[a]	.37-.47
Copper (elec or red.)[a]	.46
Columbium	120
Molybdenum (98%)	3.80-4.10
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	4-5[c]
Zirconium	
Flash Grade	11.50
Electronics Grade	15

[a]Price for —100 mesh. [c]Delivered price.
[b]Freight allowed.

OTHER NONFERROUS METALS

Cadmium (bars)	1.70
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.33[a]
Palladium	$23-24/troy oz
Platinum	$98-101/troy oz
Silver	91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	3.45
Zirconium (sheet, strip, bar)	27-35

[a]Delivered price.

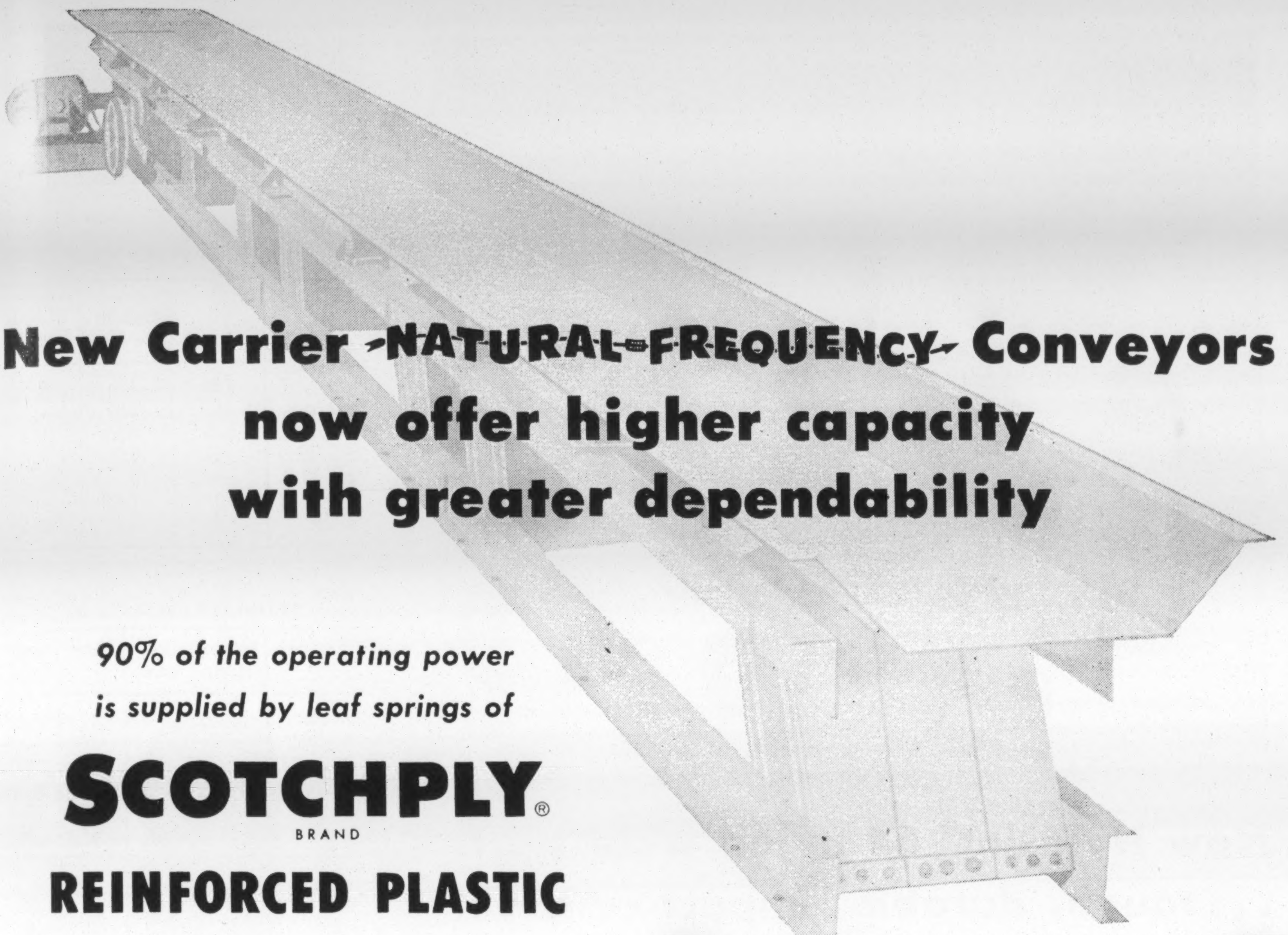
IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	74
Billets, Blooms, Slabs	
Carbon, Re-rolling	74
Carbon, Forging	92
Alloy, Forging	107
Seamless Tube Rounds	112
Wire Rods	$5.85/cwt

(continued on p 276)



New Carrier NATURAL-FREQUENCY Conveyors now offer higher capacity with greater dependability

90% of the operating power is supplied by leaf springs of

SCOTCHPLY®
BRAND
REINFORCED PLASTIC

Low first cost and high conveying speed (up to 90 feet per minute) are only two of the reasons why Carrier "Natural-Frequency" Conveyors are the choice of more and more engineers.

An eccentric drive puts the trough into motion to move loose bulk materials by a series of high frequency "pitches and catches". This means screening and sizing can be done while conveying. Troughs may be covered for dust-proof construction. And drive stresses are distributed uniformly along the whole length of the conveyor by cantilever-type leaf springs.

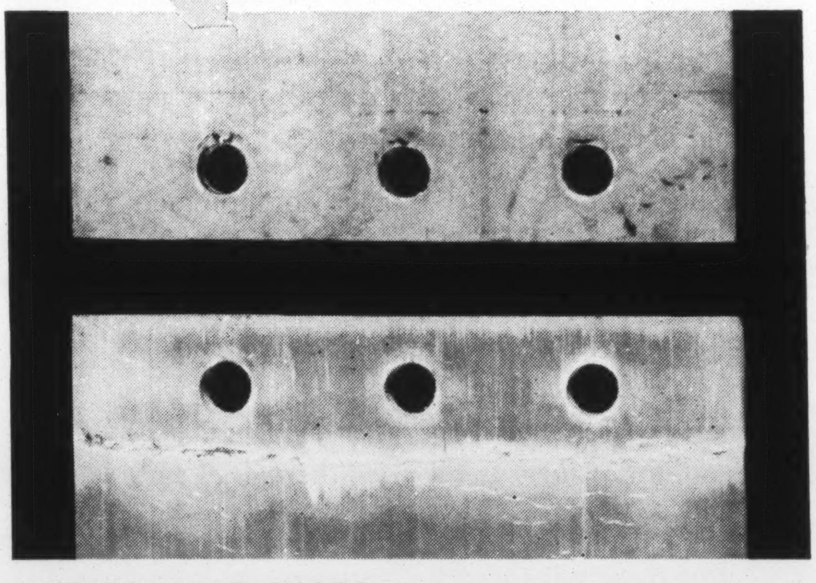
Choosing the leaf-spring material was no easy job. Carrier tested steel, resin impregnated laminated hardwood and other reinforced plastic materials. They found only "SCOTCHPLY" Reinforced Plastic answered every requirement: strength, resistance to fatigue and corrosion.

"SCOTCHPLY" Reinforced Plastic is an entirely new type high strength, light weight structural material with thousands of non-woven fine glass filaments uniformly aligned under even tension. 3M's background in adhesives has been used to achieve a lasting bond between the specially formulated thermosetting epoxy resin and the glass filaments.

3M research offers other resin systems for specific uses.

The terms "SCOTCH" and "SCOTCHPLY" and the plaid design are registered trademarks for the pressure-sensitive adhesive tapes and reinforced plastic made in U.S.A. by Minnesota Mining and Mfg. Co., St. Paul 6, Minn.—also makers of "SCOTCHLITE" Reflective Sheeting, "Thermofax" Copying Products, "3M" Abrasives, "3M" Adhesives, and many other products.

PRODUCT OF 3M COMPANY RESEARCH



UNRETOUCHED PHOTO shows results of test at Carrier Corp. Top: Unidirectional "SCOTCHPLY" Reinforced Plastic spring with isotropic faces was without damage after three weeks of running at double normal load. Bottom: Unidirectional polyester spring broke down after 15 hours.

For complete information on the Carrier "Natural-Frequency" Conveyors, write Carrier Conveyor Corporation, Louisville 2, Kentucky.

For complete information on "SCOTCHPLY" Reinforced Plastic, write 3M Company, Dept. PB-47, St. Paul 6, Minnesota.

For more information, turn to Reader Service Card, Circle No. 429

New Nylasint® 64 nylon wear parts ... tough, durable, impact-resistant

Nylasint 64 is the newest in the family of Nylasint finely divided nylon powders, bringing new advantages to wear parts formed by the technique of cold pressing and sintering.

Nylasint powders, which can be compounded with various fillers such as molybdenum disulphide or graphite, form parts with these superior properties:

- *High wear and abrasion resistance*
- *Low surface friction*
- *High modulus—resist deformation under load*
- *Low hygroscopic and thermal expansion*
- *High heat distortion temperature*

... plus these advantages in processing:

- *Uniform shrinkage, accurate profiles*
- *Require no degating, have no flash lines*
- *Minimized possibility of stress spots or internal strain*
- *Economical mass production*

For detailed information on your applications, write to National Polymer Products, Inc., Reading, Pa.

Licensed Fabricators and Design Engineers:
Dixon Sintaloy, Inc., Stamford, Conn.
Halex Corp., Plymouth, Mich.

p POLYPENCO

NATIONAL POLYMER PRODUCTS, INC.
A Subsidiary of The Polymer Corporation
Reading, Pennsylvania

For more information, turn to Reader Service Card, Circle No. 615

PRICES AND SUPPLY

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	4.85	7.25	6.85
Sheet, H.R.	4.67	6.90	—
Sheet, C.R.	5.75	8.52	—
Strip, H.R.	4.67	6.95	7.75
Strip, C.R.	6.85	10	14.55
Bar, H.R.	5.07	7.42	6.12
Bar, C.F.	6.85	—	8.32

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate[b]	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.36-.40	.41-.46	.45-.49	.50-.56
321[a]	.45	.53	.58	.63
347[a]	.54	.62	.67	.76
Martensitic				
410[a]	.27	.33	.34	.39
416	.28	.33	.35	.47
403	.31	.36	.39	.47
420, 440	.33	.40	.44	.60
Ferritic				
405, 430, 430F[a]	.28-.29	.33-.34	.35-.36	.39-.50
442	.32	.38	.40	.54
431	.36	.42	.44	.54
446	.38	.45	.46	.67
High Mn				
202[a]	.35	.41	.43	.47
Extra-Low C				
304L	.47	.53	.56	.61
316L	.64	.74	.78	.82
Precip Hard.				
17-7PH	.55	.65	.72	.77-.82

[a] Ingot prices approx 60% of forging billet price.

METAL POWDERS ($/lb)[a]

Sponge Iron	.09-.10
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.34
Stainless Steel	
304	1.05
316	1.40

[a] Price for —100 mesh.

IRON ($/gross ton)

Pig	62.50-63.50

(continued on p 278)

HEXAGON-HEAD CAP SCREWS

In a full size range
and two types:
low-carbon bright and
high-carbon heat-treated;
Coarse or fine threads

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service Card, Circle No. 388

STOP

weighing epoxies...

use the HYSOL

Adhesive Kit

Some Current Uses:

Repair metal and plastic castings • Bonding marble Automobile body repair • Positioning drill bushings Sealant for phenolic housings • Aircraft hull repair Field repair of sporting equipment • Boat repair Sealant for honeycomb panels • Plant Maintenance Seam sealant for swimming pools • Machine repair Adhesive for glass bonded mica • Laboratory repair Replacement for solder • Repair of china and glass Installation and repair ceramic fixtures • Repair and edge sealant for formica panels • Adhesive and sealant for model work • Repair plastic and plaster contour maps

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HYSOL
product of HOUGHTON LABORATORIES INC

For more information, turn to Reader Service Card, Circle No. 592

PRICES AND SUPPLY

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	9.70-9.95
Electrolytic (0.25-0.75 lb)	8.40-9.15
Black Plate	7.50-7.60

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.50
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.50
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.00
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.50
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.50
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.50
Vinyl	1.0	2.0	2.50
Acrylic	1.0	2.0	2.75

[a] Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.

[b] Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

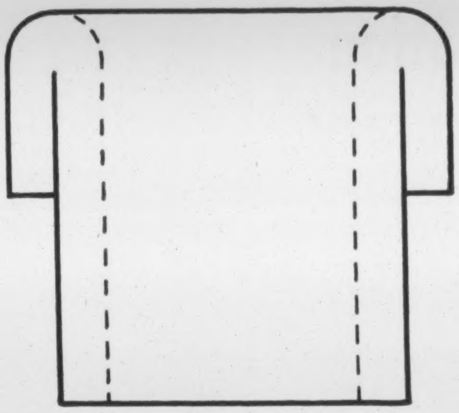
(continued from p 271)

similar ventures will probably result in even wider use of zinc.

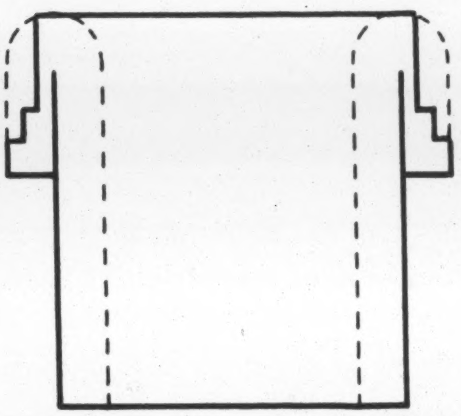
The supply-demand situation is presently balanced and Mr. Kimberley foresees "no demand which the zinc industry will not be able to handle."

(more Prices & Supply on p 280)

more proof of *Carpenter* quality . . . at no extra cost



Reverse bend **is made on one end, doubling the pipe back on itself.**



Machining **is then performed on the doubled back part of the pipe as shown in photo.**

Carpenter Stainless Pipe shows fabrication savings!

Only the highest quality stainless pipe and tubing with outstanding uniformity in properties and dimensions can take this punishing reverse bend (see sketches) and succeeding machining operations. The part is made from 2″ Carpenter Schedule 40 pipe, and must meet close tolerance requirements consistently.

If more of this kind of proof is needed, call your nearest Carpenter Distributor today. He has the service and stock to serve you right!

MEMBER FORMED STEEL TUBE INSTITUTE

The Carpenter Steel Company
Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

more than corrosion resistance

Stainless Tubing & Pipe

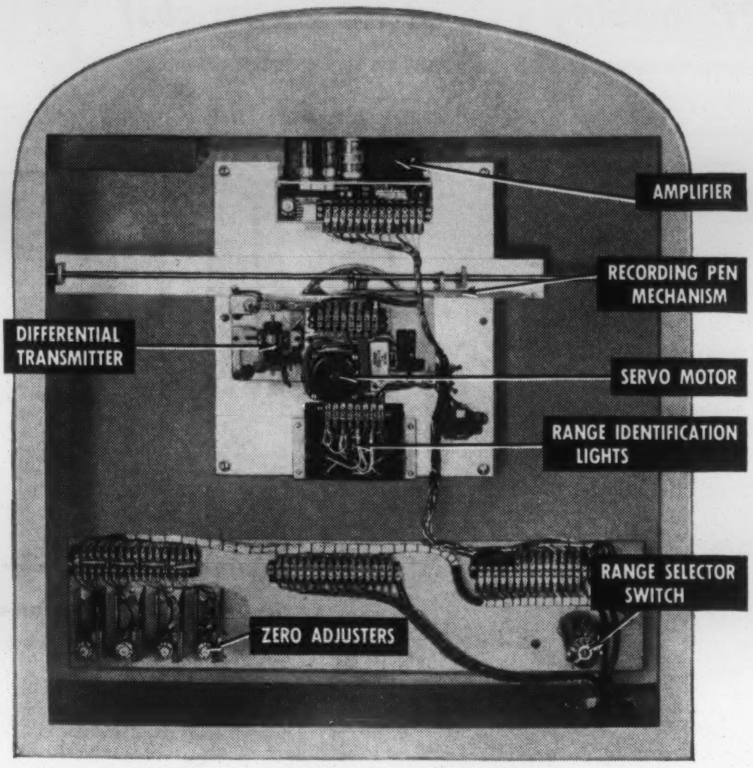
For more information, turn to Reader Service Card, Circle No. 596

UNMATCHED SIMPLICITY

plus

Ease of
Operation
& Accuracy

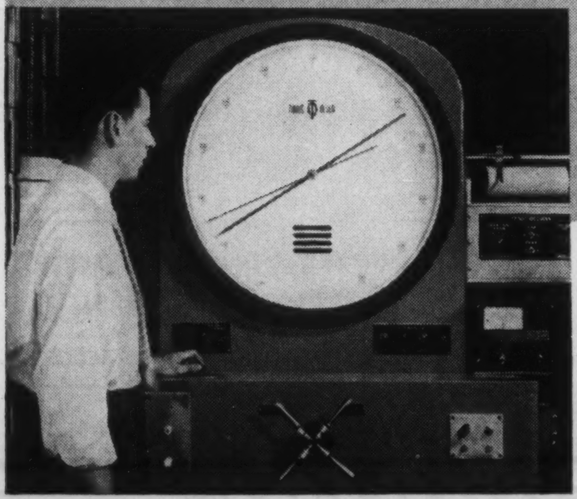
TINIUS
OLSEN
ElecTOmatic
TESTING
MACHINES



Rear view of the Olsen SelecTOrange Indicating System, used in all ElecTOmatic testing machines.

For functional simplicity, sensitivity, speed of response and ease of operation, the SelecTOrange Indicating System used in all Olsen ElecTOmatic testing machines is years ahead of the field. This patented electronic null balance system provides a minimum of 100 to 1 ratio of testing ranges and assures foolproof accuracy. By flipping the selector switch, the range can be changed at any time without interrupting the test. When an Olsen load cell is used, range capacities as small as 50 grams represent full scale on the large color coded dial.

Positive testing speeds even under load and unlimited stroke are among the many other features that make Tinius Olsen ElecTOmatics your best testing machine buy.



Get the facts from Olsen.

Details given in new 40 page Bulletin 54. Write today for your free copy.

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Testing and Balancing Machines

For more information, turn to Reader Service Card, Circle No. 447

What's Happening in Prices and Supply

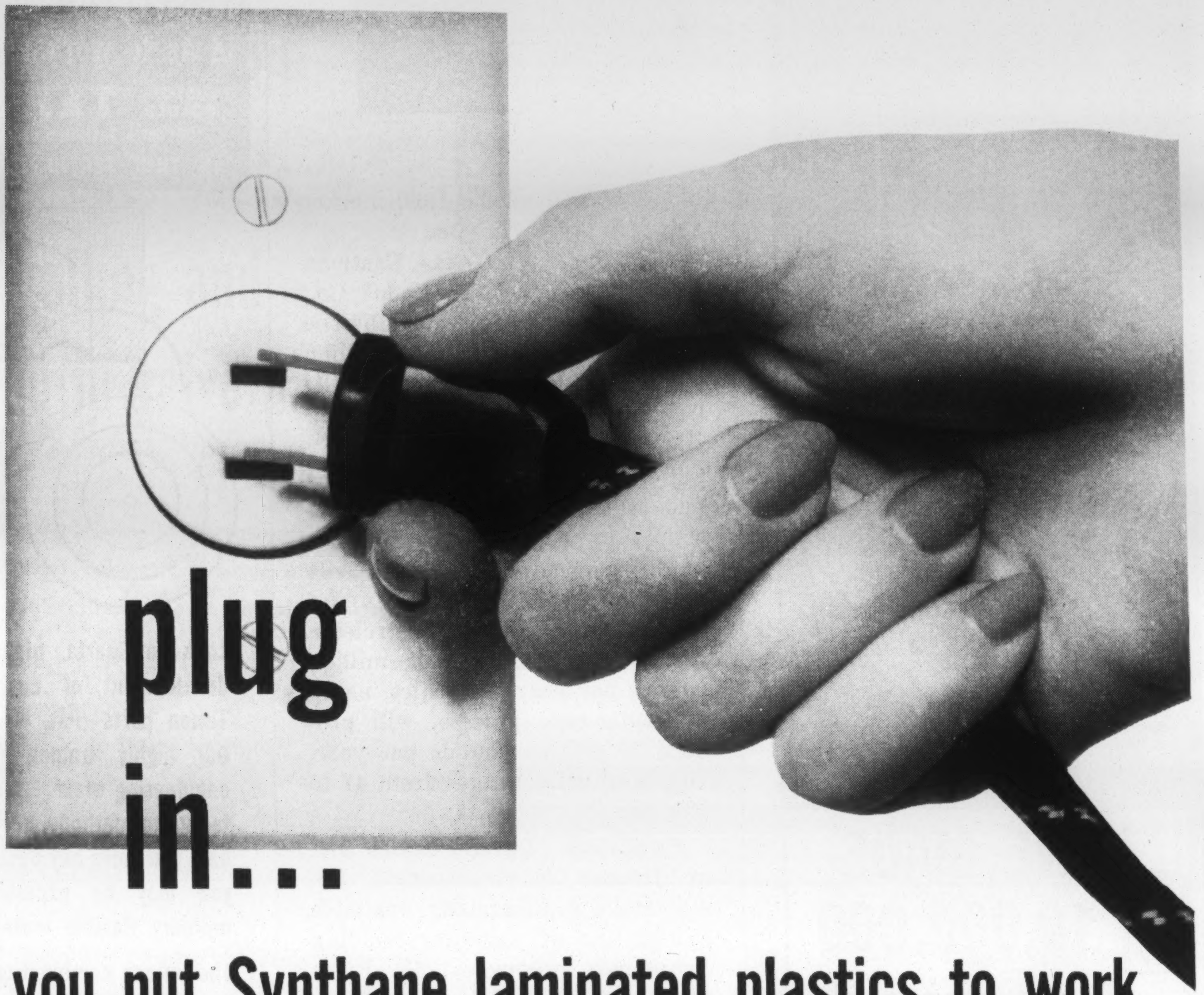
Tungsten — Two General Electric Co. technicians are reported to have found what may be a rich deposit of strategic tungsten in Eastern New York State. According to the report, the deposit extends for at least 150 miles, and at two test points the belt of ore is 30 ft deep. Should the deposit be commercially feasible, it could make the United States independent of foreign sources for tungsten. The best known deposits are in China.

Steel — Beginning with April shipments, the Cleveland-Cliffs Iron Co. price of Lake Superior iron ore will be increased by 60¢ per ton, or about 5%. All other producers of Lake Superior ore are expected to follow suit and since 70% of all iron ore consumed by the domestic steel industry comes from this region, steelmaking costs will be increased.

Sharon Steel Corp. has completed a new $14 million slabbing and blooming mill, increasing its ingot rolling by 1,200,000 tons a year. Sharon's total ingot capacity is expected to exceed 2 million tons by the end of 1957.

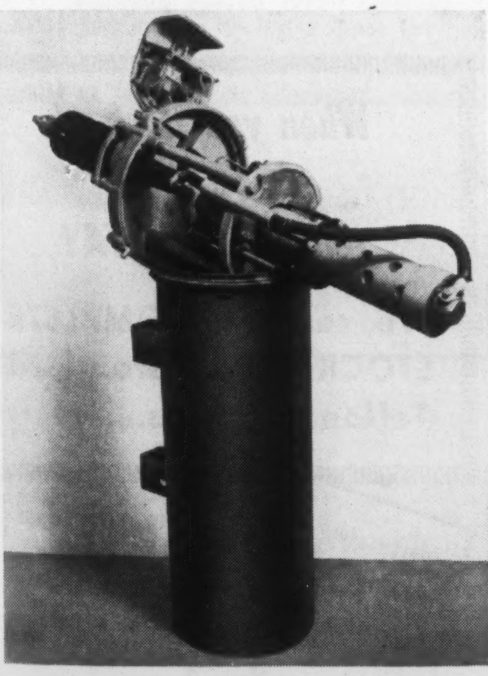
Silicon — Du Pont expects to produce annually about 50,000 lb of semiconductor grade silicon once its new plant is completed early in 1958. The material, a vital part of electronic and electrical devices, sells for $320 per lb. At present, Du Pont is the nation's only producer of this "hyper-pure" silicon.

Aluminum—The American Die Casting Institute estimates that the die casting industry will produce 450 million pounds of aluminum die castings in 1957. Moreover, it estimates that by 1960 this figure will grow to 750 million lb. This would be 1/8 of all aluminum, primary and secondary, produced domestically and equiv-



plug in...

and you put Synthane laminated plastics to work



Automatic Circuit Recloser Parts made from Synthane sheet and tube provide insulation for high voltages.

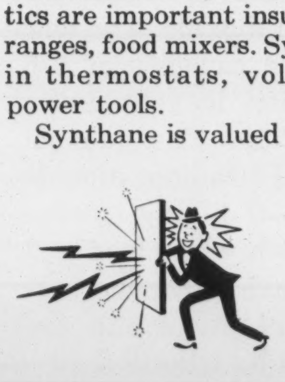
Think of the many conveniences available simply by plugging into an electrical outlet.

On both sides of the outlet Synthane laminated plastics are at work in power generation and distribution, home appliances and other electrical equipment.

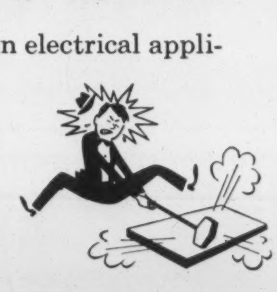
You find Synthane laminated plastics in circuit breakers, buss bar coverings, transformers. Synthane laminated plastics are important insulators in toasters, ranges, food mixers. Synthane is at work in thermostats, voltage regulators, power tools.

Synthane is valued in electrical applications chiefly for its high dielectric strength, low moisture absorption and low dissipation factor plus its additional properties of dimensional stability, machinability and mechanical strength. Synthane is available in over 30 standard grades in sheet, rods, tubes or you can avail yourself of our complete fabricating services.

For more information about the many properties of Synthane and how you can benefit by using Synthane materials and fabricating services, write for our product catalog. Synthane Corporation, 3 River Road, Oaks, Pennsylvania.

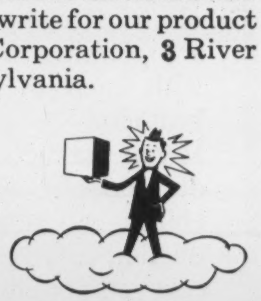


DIELECTRIC STRENGTH



IMPACT STRENGTH

HEAT RESISTANCE

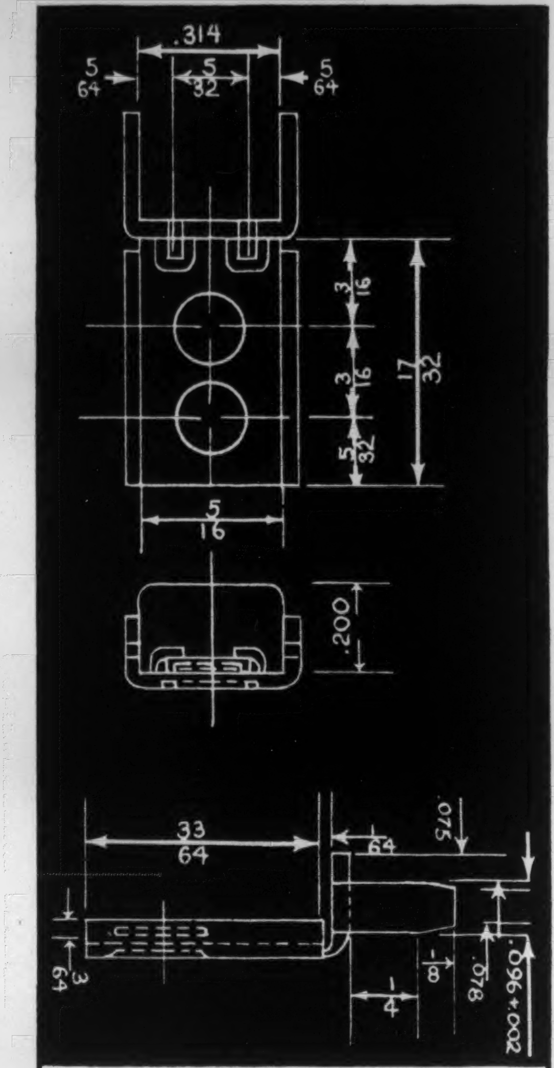


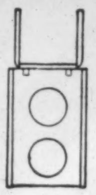
LIGHT WEIGHT

SYNTHANE S ... industry's unseen essential

SYNTHANE CORPORATION, 3 RIVER ROAD, OAKS, PA.

For more information, turn to Reader Service Card, Circle No. 392





WE MADE 10,000,000

...all interchangeable

This lug, a small metal component for an electrical device, was pierced, blanked and formed *in one operation*—at the rate of 7,000 pieces per hour . . . and at a cost so low it will surprise you.

Each of the 10 million lugs we have made over the years for one of America's great electrical companies is to exact tolerance, interchangeable with each of its 9,999,999 brothers!

If you use metal components, our modern, high-speed machines can lower *your* production costs, too. And it will cost you nothing to find out—we'll be glad to estimate on your sample or blueprint.

Write for illustrated folder

ART WIRE
AND STAMPING CO.

13 Boyden Place, Newark 2, N. J.

For more information, Circle No. 557

alent to 15% of the 1960 market for primary aluminum.

Polyethylene — Texas Eastman Co., Div. of Eastman Kodak Co., has increased its polyethylene annual capacity to 55 million pounds. In less than one year the company has increased its capacity by 15 million pounds.

Both Celanese Corp. of America and Hercules Powder Co. are supplying commercial quantities of high density (low pressure) polyethylene. Celanese, under license from Phillips Petroleum Co., will produce 40 million pounds per year. Hercules, using a Ziegler-type process, will produce 30 million pounds per year. Hercules' price ranges from 47 to 53¢ per lb.

Polyesters—Durez Plastics Div. of Hooker Electrochemical Co. will make commercially available a new line of polyester molding compounds (see page 175). Price of the new material ranges from 42 to 77¢ per lb, depending upon quantity.

Polystyrene foam—Price reductions ranging from 10 to 15% on standard board forms of expanded polystyrene have been announced by Dow Chemical Co. The reductions apply to 3, 8 and 9-ft lengths and 12 and 16-in. widths.

Paints—Du Pont plans to build its third plant for the manufacture of titanium dioxide. The new plant will have a capacity of 125 tons a day when it gets under way in early 1959. The unusual growth in use of titanium dioxide is due to its great hiding power; ten times as much white lead and five times as much lithopone pigment are required to attain the opacity provided by titania.

Nylon—About 64 million pounds of nylon tire yarn were used in 1956—about 25% more than was consumed in 1955. Only 8 million pounds of nylon tire yarn were consumed in 1952.

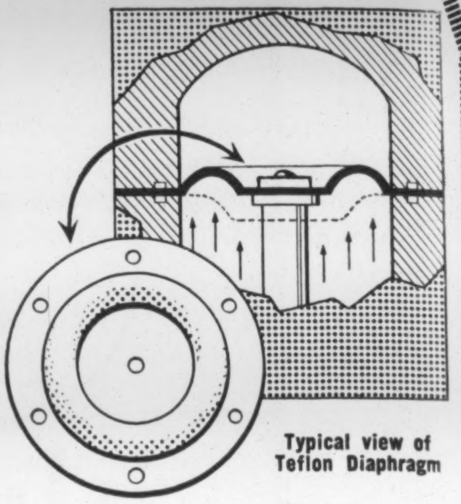
Methyl methacrylate—Hercules Powder Co. and Imperial Chemi-

for NEW PERSPECTIVES... let SPARTA help you put ideas to work with

CUSTOM MOLDED TEFLON*

*DuPont's Tetrafluoroethylene Resin

IN THIN SECTIONS AND SHAPES!



Typical view of Teflon Diaphragm

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How Armco 17-4 PH Stainless cuts costs, resists galling and corrosion in valve parts

Ruggedness and resistance to corrosion are prime requisites for relief valves that serve boilers and pressure lines in refineries and chemical plants.

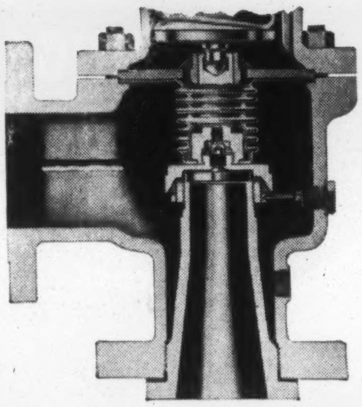
Farris Engineering Corp., the manufacturer of this safety valve, uses special Armco 17-4 PH Stainless Steel for the disc and stem retainer . . . the core of the unit. Here's why:

1. Costs are lower because there is no re-machining or grinding after hardening. No distortion occurs during low temperature heat treatment.

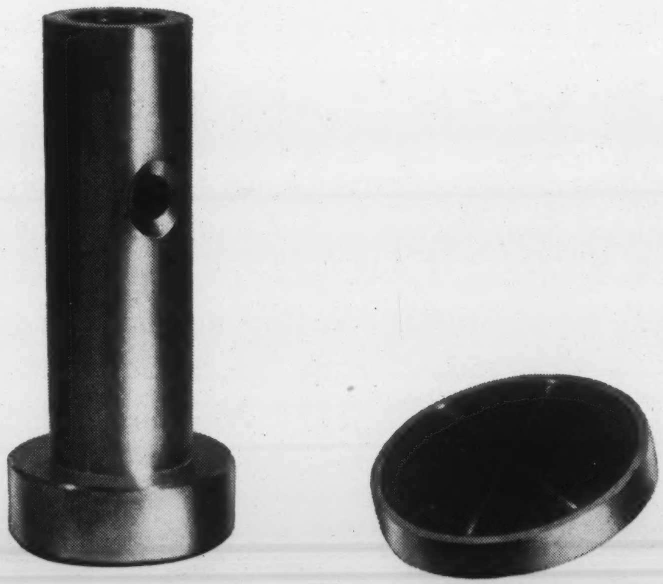
2. Parts made of Armco 17-4 PH have high hardness and resistance to galling.

3. Good resistance to impact is provided by this special steel.

4. Since Armco 17-4 PH has a lower coefficient of expansion than the non-hardenable stainless grade used in adjoining parts, a cause of "hanging" is eliminated.



Stem retainer and disc of Armco 17-4 PH Stainless form the tough "heart" of this relief valve, serving on a pressure line in a chemical processing plant. Both parts shown were finish-machined before hardening because this special steel doesn't distort during heat treatment.



ELIMINATE 4 SHOP OPERATIONS

Finish-machine, then heat treat at low temperature —and a part made of Armco 17-4 PH is ready for assembly. You can eliminate re-machining or grinding, stress relieving, pickling, and straightening operations.

Armco 17-4 PH is available in billets, bars and wire. A companion grade, Armco 17-7 PH Stainless, is produced in sheets, strip, plates, billets, bars and wire. Write us at the address below for full information about these special new precipitation-hardening stainless steels.

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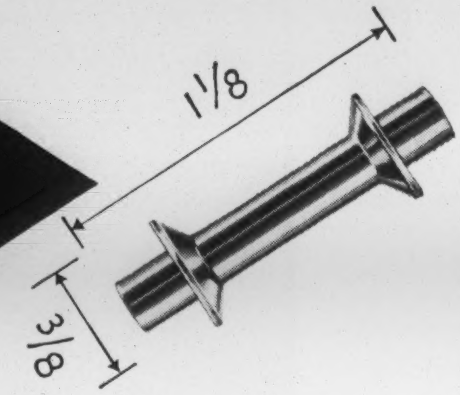

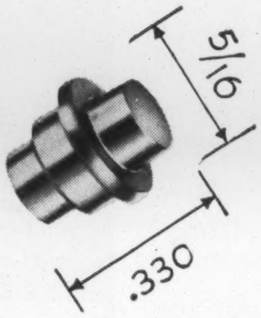

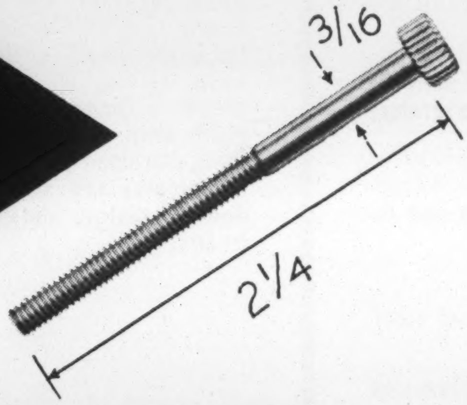

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cal Industries, Ltd., have formed a jointly owned company, Hawthorn Chemical Corp., which will produce 35 million pounds of methyl methacrylate annually. ICI will probably continue to produce the material on its own. At present, the major U.S. suppliers are Du Pont and Rohm & Haas.

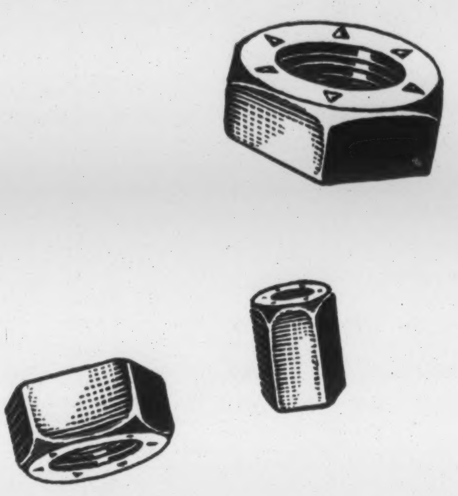
Tellurium—American Smelting and Refining Co. has announced an increase of 15¢ per lb for powdered tellurium in 100-lb lots, the first price increase for tellurium in 3½ years. The new price is $1.65 per lb.

Tantalum, columbium—Fansteel Metallurgical Corp. will build a $6,500,000 tantalum-columbium plant on a 113-acre site near Muscogee, Okla. The new facility is expected to increase Fansteel's tantalum capacity by 50% and its columbium cpacity by 150%.

Packaging materials—In pointing out the important position the packaging industry occupies in terms of materials use, John Warren, technical adviser of American Management Assn.'s packaging division, offered the following statistics: the packaging industry uses 99% of the nation's cellophane production; 80% of its metal foil (about 7% of the aluminum industry's entire output); 70% of all glass other than flat glass; and 55% of the paper and paperboard output.

Price Schedule for Radiation Service

The first private rate schedule for commercial atomic radiation is available from Radiation Applications, Inc. Industrial concerns may purchase gamma radiation from the 1350 curie cobalt-60 source for a base charge of $8 per hr; for continuous 24-hr use the price is $64. Loading charge is $2.50 per operation and the base rate for supervision of experiments is $7.50 per hr.



For over 50 years, leading manufacturers in all the major industries have used Gripco lock nuts to simplify production, lower manufacturing and maintenance costs and to improve the durability of all kinds of assembled products. To maintain this enviable reputation for outstanding product quality, the Grip Nut Company of South Whitley, Indiana, uses quality-controlled Youngstown Scrapless Nut Wire and Bars as basic raw material.

Because it comes to your plant free from all piping, injurious seams, laps, die marks, internal tearing and cupping, and non-metallic inclusions—Youngstown Scrapless Nut Quality Wire will provide increased production with fewer rejects which adds up to a healthy over-all profit boost. Also, its smooth coating extends die life thus minimizing costly die replacements.

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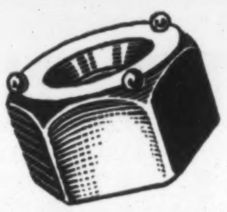
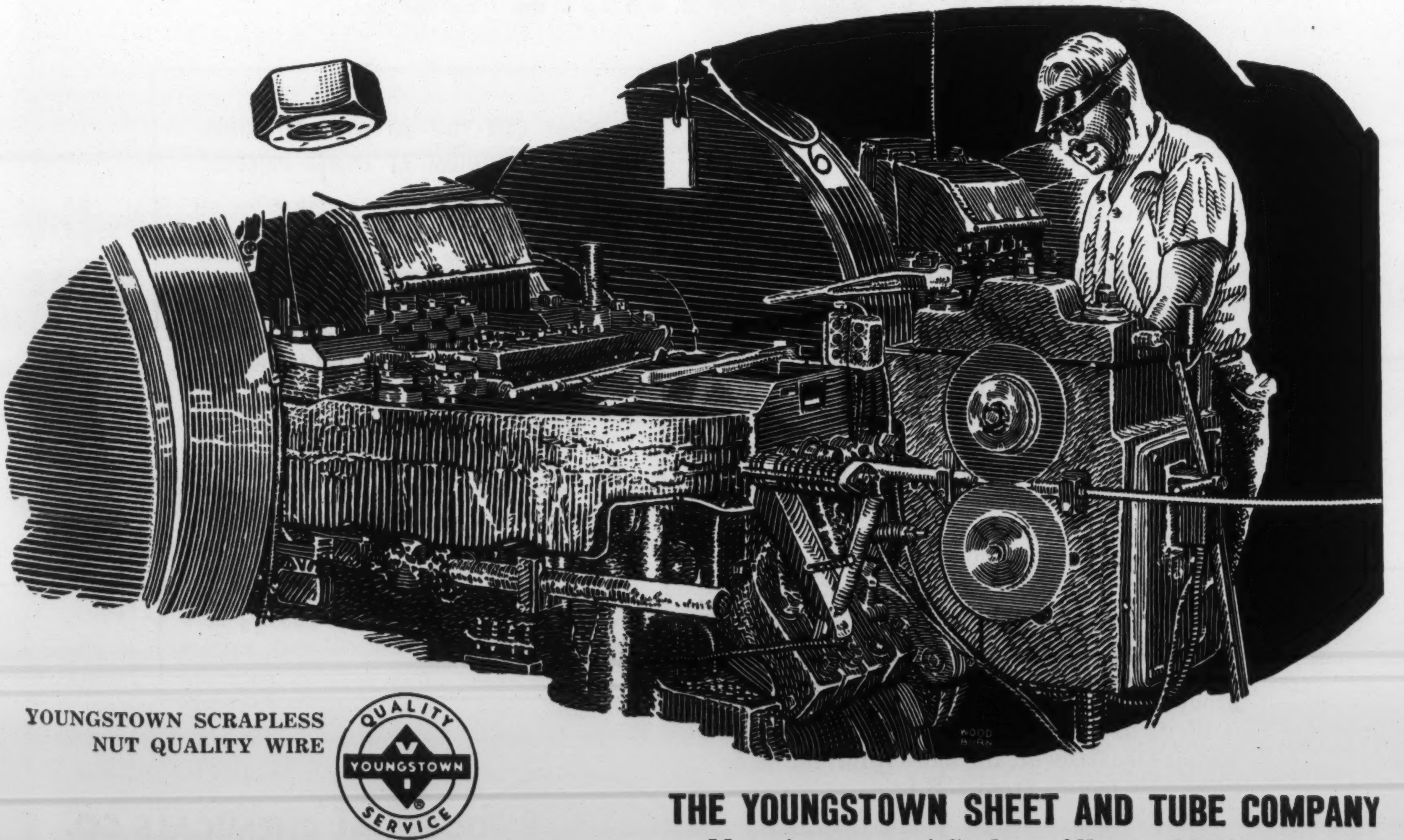
Helps Maintain Quality of GRIP *Lock Nuts*



Youngstown Scrapless Nut Quality Wire is provided in special resulphurized steels as well as in standard AISI grades. Cold Heading Bolt Wire, of the same high Youngstown quality, is also available in all standard carbon and alloy analyses. Why not phone or write to our nearest District Sales Office for additional information or metallurgical assistance?



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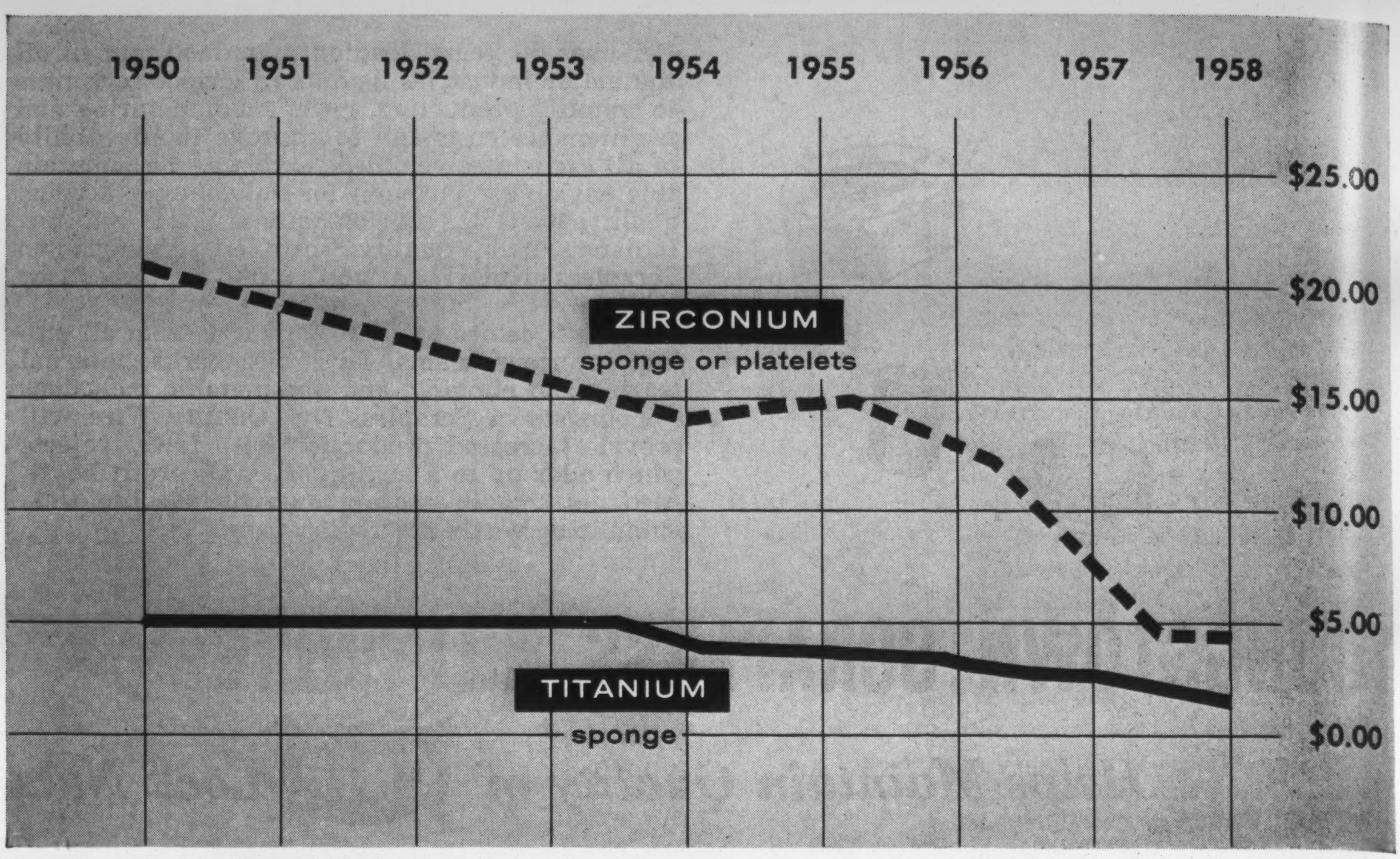

Available soon at lower prices

ZIRCONIUM AND TITANIUM FOR INDUSTRIAL USE

Now is the time to do some new thinking about titanium and zirconium. These metals with their many advantages will soon be *much more plentiful* at *much lower cost.* Reason: U.S.I. will be coming onstream shortly with a 10-million pound per year titanium plant AND a zirconium plant which will supply one million pounds of that metal to industry.

Zirconium from the new plant will sell for considerably less than current prices. Here's why: U.S.I. will use the most economical production technique ever developed for reducing metallic chlorides – a semi-continuous sodium reduction process. This process has possibilities of reducing titanium prices in the future as well.

So think again about zirconium and titanium for industrial equipment. Remember that they are lighter than other metals – a pound goes farther. Remember that they are more durable than other metals—a fabricated product lasts longer.

Write to Bill Greenleaf, U.S.I. Manager of Metals Department, for more information on these new metals from U.S.I.

WHAT CAN YOU DO WITH TITANIUM AND ZIRCONIUM AT LOWER PRICES?

In the future titanium sponge prices are expected to drop to about $2.00 a pound, with a corresponding drop in the prices of mill products. At these prices the exceptional strength-to-weight ratio and corrosion resistance of titanium can be put to work in the aircraft, marine, automotive, chemical and allied fields.

Or consider the eventual price of U.S.I. commercial grade zirconium: an estimated $3.00 a pound for platelets and 2 or 2½ times this price for the average mill product. This price will make zirconium practical for chemical equipment, marine equipment, food equipment and surgical metals among other uses. Zirconium has light weight, high structural strength, excellent corrosion and heat resistance; and reactor-grade zirconium has outstanding nuclear properties.

Chemical Progress Week — April 8-12

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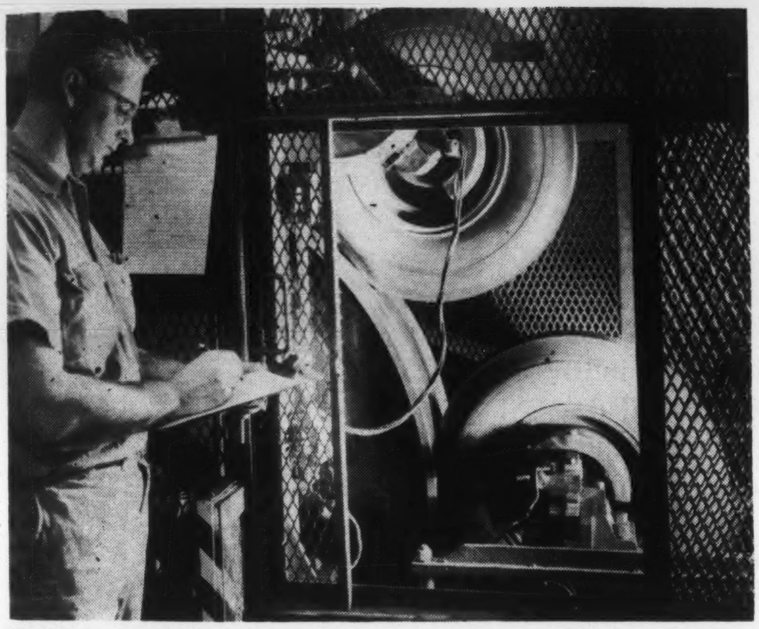
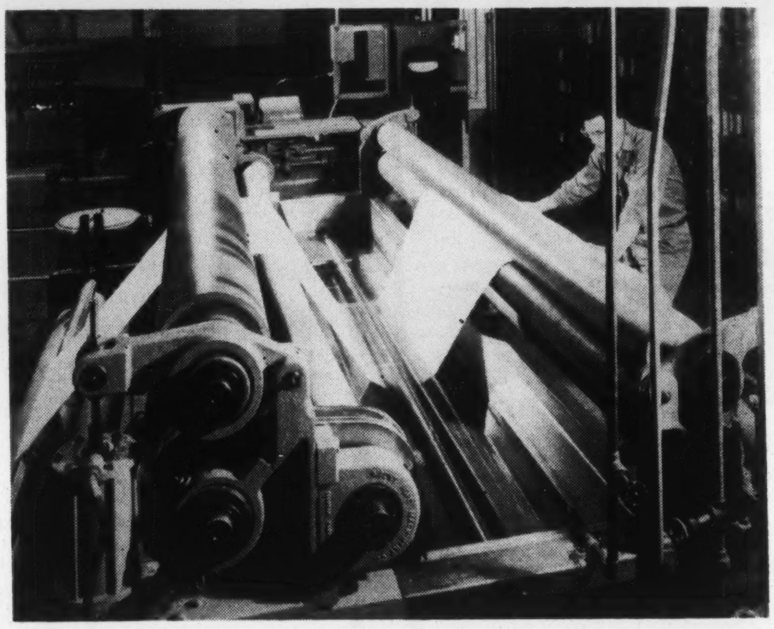
News OF INDUSTRY



***Tires** are tested at various loads and inflation pressures to determine performance of synthetic tire cord.*



***Nonwoven felt** of synthetic fibers in final production step. Density, hardness and other properties can be varied by controlled changes in processing.*

Industrial Use of Synthetic Fibers Studied in Textile Laboratory

■ Du Pont has taken the lid off a heretofore unpublicized research laboratory engaged in a broad scale study of industrial applications of synthetic fibers. Established in 1954 by Du Pont's Textile Fibers Dept., the laboratory has been instrumental in the development of fibers for such applications as tire cord, plastics reinforcement, nonwoven fabrics and felts, paper, bearings, coated protective coverings, filling materials and mechanical rubber goods.

One of the areas in which the lab has been particularly valuable is automobile tire research. The lab has complete tiremaking facilities, including a dip-stretch unit that can process from 1 to 64 cords at a time. With this laboratory-scaled replica of a large commercial unit, researchers are able to vary conditions widely to determine effect on cord or to develop improved processes for tire manufacture. Two specially devised test wheels duplicate any one condition of tire service, and each of the 45 test tires produced weekly is used to test some new concept of tire construction.

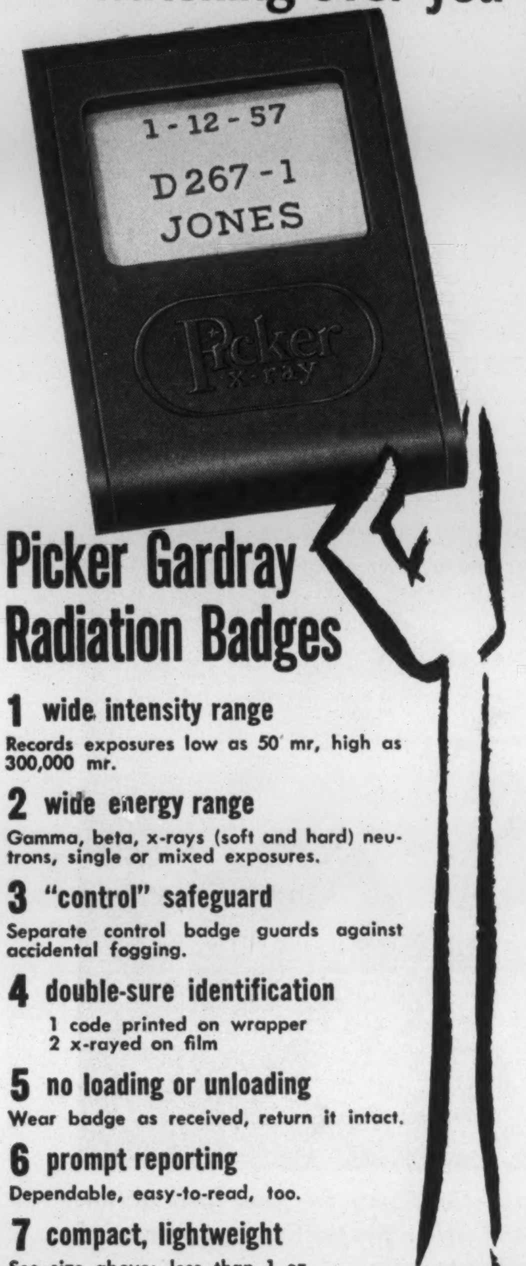
Also available in the laboratory are Instron testers with loading

Plan to Attend the Design Show

1. To hear talks about latest developments in materials and processes.
2. To see exhibits of new products and designs.
3. To meet and talk with people who may be able to answer your materials or other design problems.

The Design Engineering Show and Conference will be held at the New York Coliseum May 20-23. See the May issue of MATERIALS & METHODS for complete registration details, list of exhibitors and program of technical sessions.

9 ways better at watching over you



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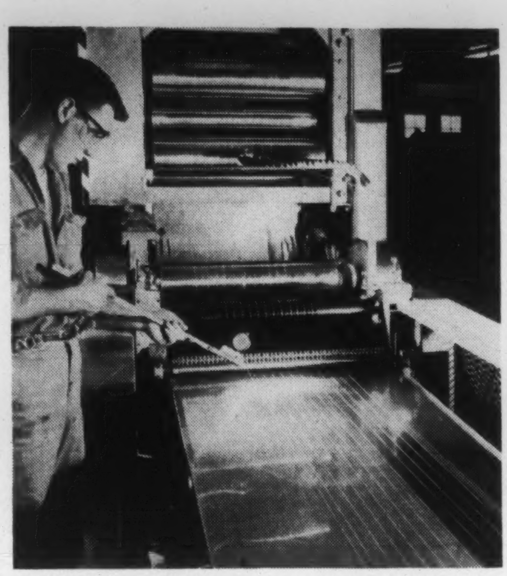
News OF INDUSTRY



Nylon cord *for tires is checked prior to application of adhesive.*

capacities ranging from 10,000 lb of thrust or tension to a few grams — the latter suitable for measuring the tenacity of individual fibers. Another special device determines fatigue resistance of cord by recording the number of twists sustained by a short length of hose reinforced with the cord before it ruptures and allows compressed air to escape from within it.

The Laboratory is under the direction of Richard W. Nebel.

AIME Conference To Be Held This Month

The American Institute of Mining, Metallurgical and Petroleum Engineers, in cooperation with the High Temperature Committee of the Institute of Metals Div., will hold a two day conference on high temperature materials in Cleveland April 16 and 17.

Papers and discussions will cover cobalt, nickel, chromium and molybdenum-base alloys; refractory metals; SAP-type materials; cermets and hard metal compounds; ceramics; graphite and methods of testing; effect of atmosphere on high temperature properties; and effects of vacuum melting and casting on properties.

(more News on p 290)

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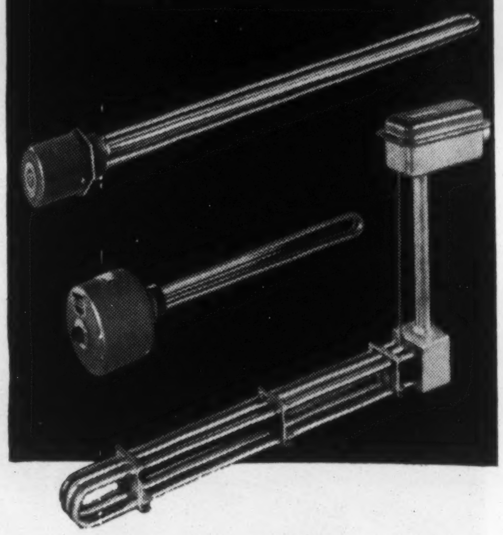

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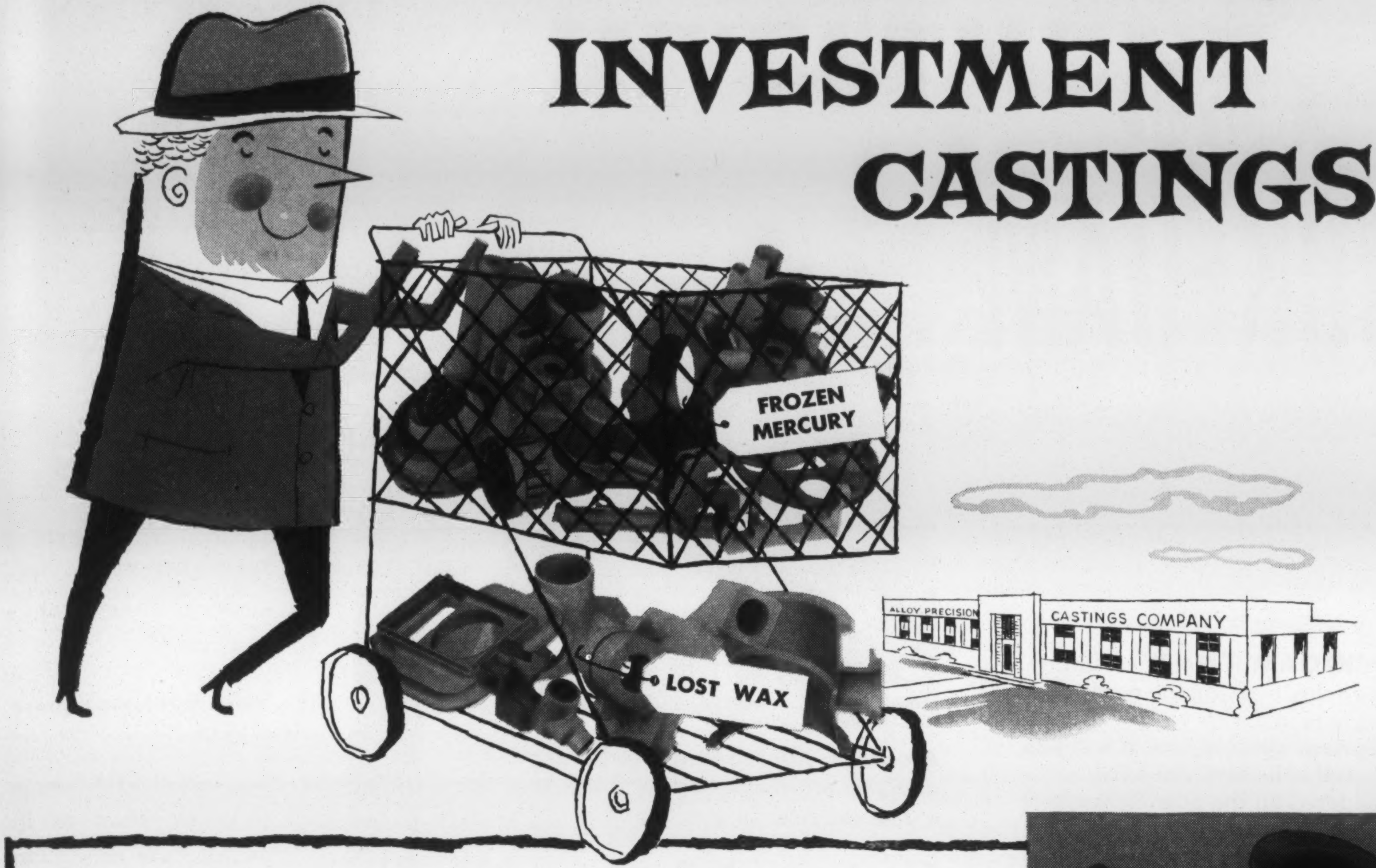

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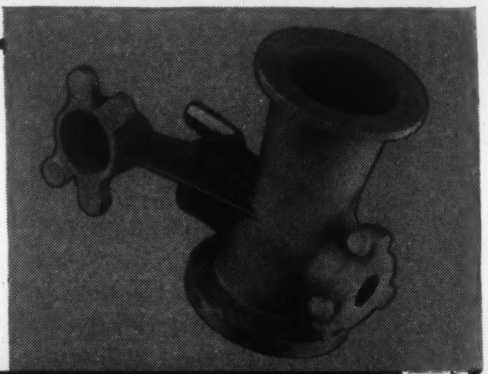

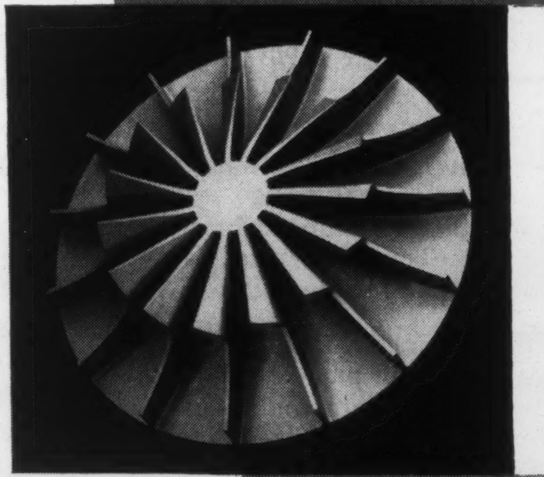

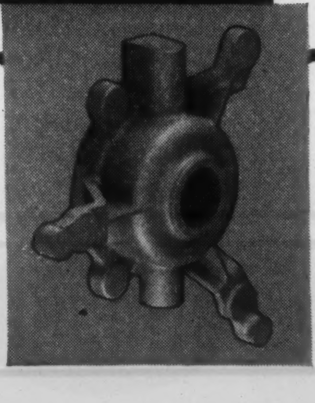

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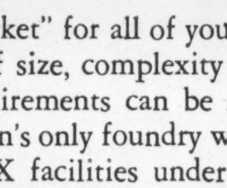

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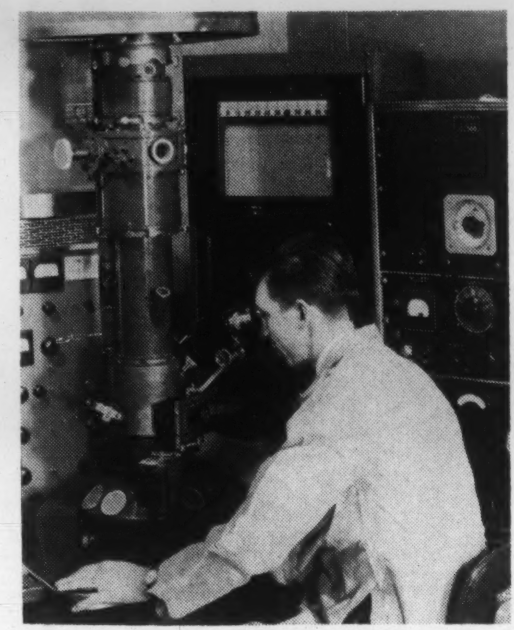
News OF INDUSTRY



***Electron microscope** modified for analysis of steel specimen areas only a few microns in diameter.*

Electrons, X-Rays Aid Steel Studies

A new metallurgical research technique permits analysis of steel specimen areas 10,000 times smaller than is possible by any other method. The technique makes use of an electron microscope modified to excite x-ray emission from a region as small as a few microns in diameter.

Broad applications

The new method, being studied and modified at U. S. Steel Corp.'s Fundamental Research Laboratory, has wide potential application in metallurgy for 1) studying intergranular corrosion, 2) analyzing segregation of alloying elements among the metallic phases and along metallic grain boundaries, 3) measuring interdiffusion during welding and plating, and 4) determining the composition of fine precipitate particles.

The technique is as follows: steel samples are placed in a specimen chamber in the face of the 4-ft. electron column. An electron beam, accelerated to approximately 30,000 v., is focused by three electrical lenses. The electron beam crossover point, formed

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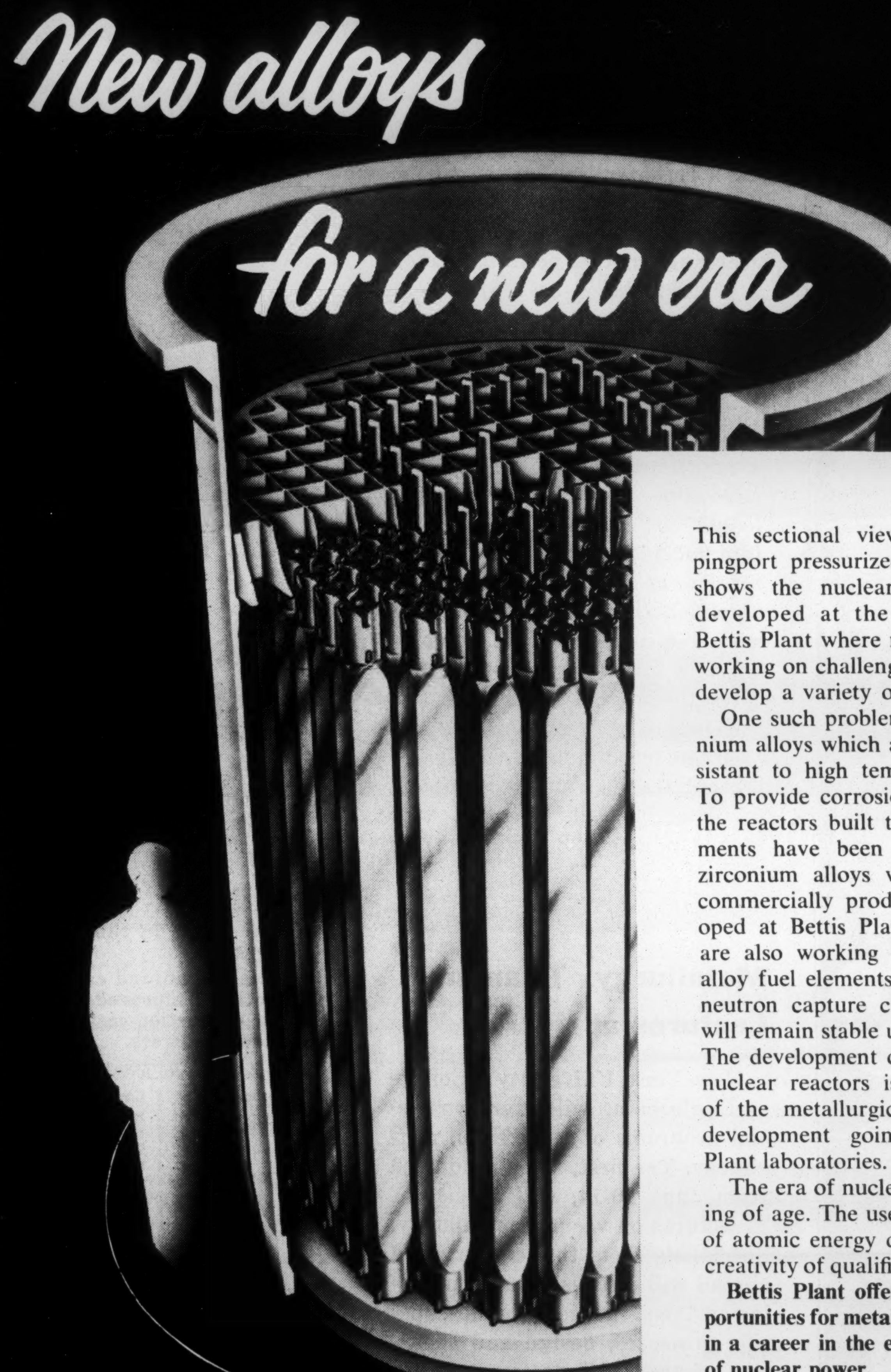

This sectional view of the Shippingport pressurized water reactor shows the nuclear fuel elements developed at the Westinghouse Bettis Plant where metallurgists are working on challenging problems to develop a variety of reactor alloys.

One such problem is to find uranium alloys which are corrosion resistant to high temperature water. To provide corrosion protection in the reactors built to date, fuel elements have been clad with new zirconium alloys which were first commercially produced and developed at Bettis Plant. Metallurgists are also working to find uranium alloy fuel elements that have a low neutron capture cross section and will remain stable under irradiation. The development of new alloys for nuclear reactors is but one phase of the metallurgical research and development going on in Bettis Plant laboratories.

The era of nuclear power is coming of age. The useful advancement of atomic energy depends upon the creativity of qualified personnel.

Bettis Plant offers challenging opportunities for metallurgists interested in a career in the expanding industry of nuclear power.

If you are an outstanding young metallurgist, interested in advanced degree study, write today for a descriptive brochure which outlines the details of our unique doctoral fellowship program.

Please address resumes to: Mr. M. J. Downey, Westinghouse Bettis Plant, Dept. A-144, P. O. Box 1468, Pittsburgh 30, Pennsylvania.

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by the objective lens, is focused by a repeater lens on the surface of the steel sample. An optical binocular microscope and mechanical stage motion permit the operator to make visual adjustments of the specimen under the beam.

Beam is analysed

The focused beam strikes a selected area of the specimen's surface, causing x-ray emission. The x-ray beam is then analyzed to determine its component wave lengths by reflection from a lithium fluoride crystal. The x-ray intensity at each wave length is amplified through a vacuum tube arrangement to activate a pen on a graph in which the x-axis indicates the wave length, the y-axis the intensity. These details are then analyzed quantitatively. At present the instrument is capable of detecting all elements with atomic number 22 (titanium) or higher.

Metallurgy, Titanium Lectures at NYU

New York University's College of Engineering will offer two special programs of lectures on metallurgy. The first, to be conducted from June 10-14, will consist of 25 lectures on vacuum metallurgy. Specialists from this country and abroad will discuss vacuum pumping systems, thermodynamics, specific processes, design and operation of arc and induction melting systems, and application of vacuum processed materials. Inquiries should be addressed to R. F. Bunshah, Associate Engineering Scientist, New York University College of Engineering, University Heights, N. Y.

The third annual titanium lecture program will be held Sept 9-13. Applications and further information can be obtained from Harold Margolin, New York University.

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SHAFTS, ROLLS, GUIDE RODS and other long-round parts

60 Case is the result of over ten years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining.

Write for literature and name of your local representative

ADVANTAGES of *60 Case*

- COST REDUCTION
- HARD BEARING SURFACE
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

TYPICAL *60 Case* PARTS

GUIDE RODS, SHAFTING, ROLLS, TRAVERSE RAILS, PISTON RODS, ARBORS, LEADER PINS, TIE RODS, KING PINS, AXLES, CONTROL RODS, GUIDE POSTS, MANDRELS, BEARING ROLLERS, SPINDLES

THOMSON INDUSTRIES, Inc.
Dept. C7, Manhasset, New York

For more information, Circle No. 419

No Chippage when you use

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SILICONE

HEAT RESISTANT FINISH

PROVED by over 25,000 TEMCO Wall Heater Installations

The upper grille of this handsome TEMCO Gas Wall Heater is finished with 7x7070 Brown SICON Silicone-Base Heat Resistant Finish. The number of louvers on this upper grille presented a chippage problem with vitreous enamel which prompted Temco to turn to SICON. Normal operating temperatures run about 350°F. but the temperature encountered on blocked flue conditions require a heat resistant finish to withstand 500°F...SICON 7x7070 Brown, on 25,000 or more Temco installations, has successfully met field performance requirements without loss of color, gloss or adhesion. Investigate other case histories of SICON—the remarkable finish that has solved over 150 heat resistant finish problems! Write today!

Sicon®

The Original Silicone Base Heat Resistant Finish

MIDLAND *Industrial Finishes Co.*

DEPT. D-1, Waukegan, Illinois

ENAMELS • SYNTHETICS
LACQUERS • VARNISHES

For more information, Circle No. 511

News OF INDUSTRY

Engineers

Harry L. Bishop, Jr. and **Sundaresan Ramachandran** have joined Allegheny Ludlum Steel Corp. as research advisers.

Robert K. Allen is now superintendent of product development at Babcock & Wilcox Co.'s Research Center; **Claude L. Huey** is the newly appointed manager of the company's Atlanta District.

Donald Bohn, designer, inventor and engineer, has retired from Aluminum Co. of America after more than 34 years of service.

Henry M. Haase has been elected vice president in charge of engineering and research, Borg-Warner Corp., York, Pa.

L. W. Newton is the newly appointed assistant to the vice president—research, Carbide and Carbon Chemicals Co., Div. of Union Carbide and Carbon Corp.

Ernest W. Neben is director of the Central Engineering Div., Pfaudler Co. **Edward W. Zoller** is now works manager of the company's Rochester Div.

Charles J. Meloun succeeds **H. J. Flaherty** as manager of engineering, General Electric's Outdoor Lighting Dept., Hendersonville, N. C. Mr. Flaherty has been named a consultant.

Wilton E. Parker is now assistant chief engineer, AiResearch Industrial Div., Garrett Corp.

Douglas W. Fuerstenau has received the Robert Lansing Hardy Gold Medal. The medal was presented by the American Institute of Mining, Metallurgical and Petroleum Engineers in recognition of exceptional promise in the field of metallurgy.

Dr. Henry H. Hausner has been elected vice president of Penn-Texas Corp.

Franklin P. Hinman has been appointed to the newly created post of operations manager, cathode ray and power tube departments, of Westinghouse Electric Corp.'s Electronic Tube Div., Elmira, N. Y.

(news of Companies on p 296)

STRAITS TIN REPORT

New developments in the production, marketing and uses of tin

MALAYAN TIN BUREAU

World consumption of tin in 1955 rose to 154,000 long tons, the greatest total since 1941. Third-quarter figures for 1956 indicate a consumption level of about 157,000 long tons. Indications point to a modest excess of production over consumption early in 1957.

★ ★ ★

Four of the six major tin-producing countries—Malaya, the Belgian Congo, Thailand and Nigeria—will probably maintain or increase their output in 1957. Significantly, Malaya alone has mined enough tin in each of the last six years to satisfy all U. S. industrial requirements. And an official of the Department of Mines in Kuala Lumpur recently stated that there is as much tin unmined in Malaya as has been taken out in the entire past.

★ ★ ★

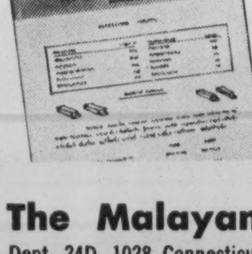
Approximately 9000 tons a year of colored ceramics are produced in this country. When tin oxide is used as an opacifier, four pounds are required for every pound of ceramics. When other materials are used as opacifiers, eight pounds are needed.

★ ★ ★

A new composite metal consisting of tin on nickel was recently developed. It is now being used in transistors in strips 0.1875 in. wide, 0.011 in. thick.

★ ★ ★

Tin is becoming progressively—and in some cases spectacularly—more useful in aeronautics. Tin cans and wind tunnels would appear to have little in common. Yet 8 million new tin cans (that's 135 boxcar loads) are now being used for temperature control in a $5 million trisonic wind tunnel in which jet planes and guided missiles will be tested.



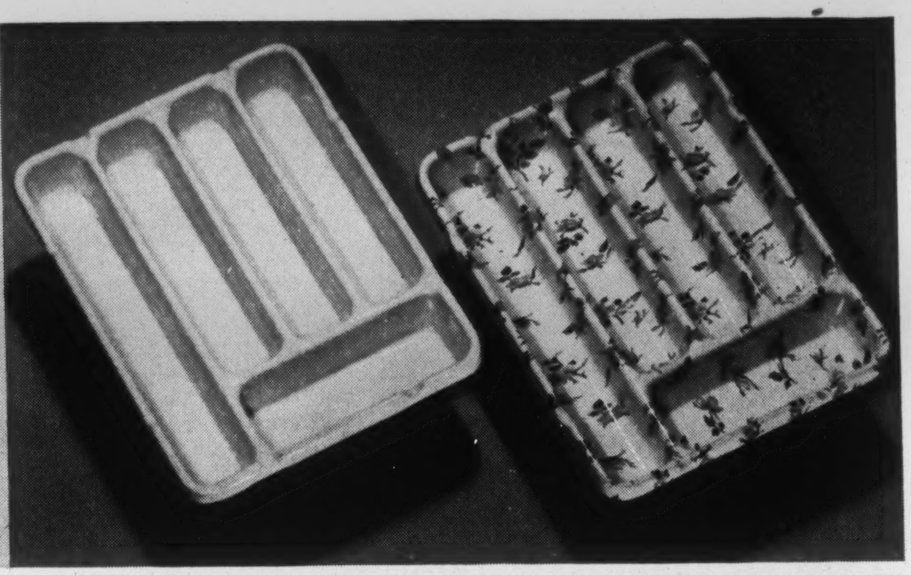
Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

The Malayan Tin Bureau

Dept. 24D, 1028 Connecticut Ave., Washington 6, D.C.

For more information, Circle No. 483

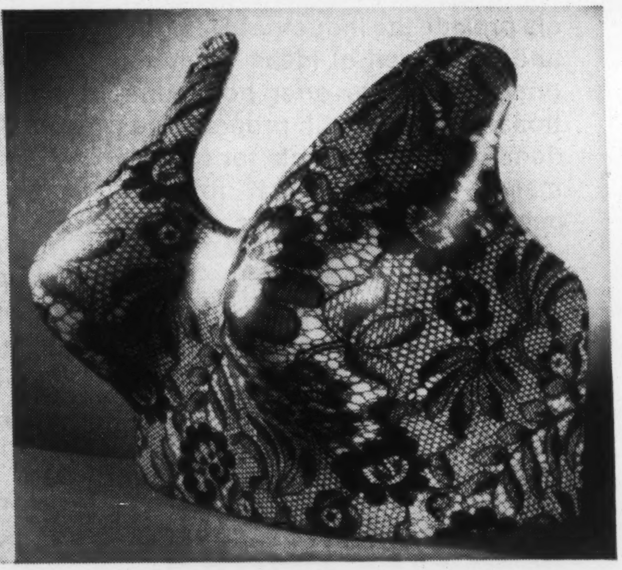
any pattern ▶



FLASH
FLASH

◀ any finish

any decoration ▶



now available in Campco sheet

Here's the bright new picture in plastic finishing. Whatever color you want . . . *in any pattern* . . . can now be supplied in CAMPCO sheets. Thanks to a special laminating process, the pattern you need is integrally – and permanently – bonded to the rubber modified styrene base.

In fact, you can have CAMPCO styrene decorated with any pattern you dream up – or photograph – for less cost than decals or other common techniques of applying designs. Several lively ones already widely used are: wood grains, polka dots, checks, laces and marble. Even simulated *textures*, like leather or cloth can be added by surface embossing. And the sheet can be formed into an almost endless range of products . . . quickly . . . and at low cost.

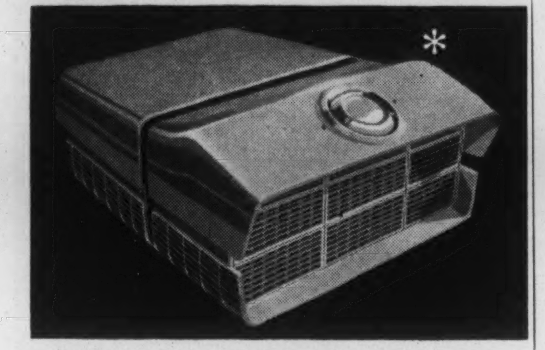
For data on how these new CAMPCO decorating ideas can make *your* product more attractive and more salable, phone or write today.

CAMPCO DIVISION
CHICAGO MOLDED PRODUCTS CORPORATION
2722 Normandy Avenue, Chicago 35, Illinois • Tuxedo 9-5520

See Campco at the National Packaging Show, April 8-11.
Booth #1272 International Amphitheatre, Chicago.

For more information, turn to Reader Service Card, Circle No. 369

Idea!

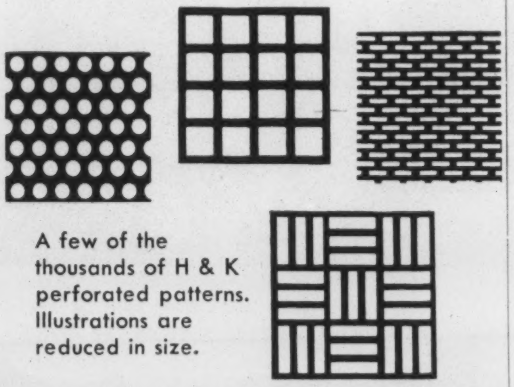


room air conditioning unit using H&K perforated metals

In the ¾ ton window air conditioner illustrated, perforated metals have been combined successfully with injection moulded plastics. The utilization, here, of new louvered perforated metals in adjustable frames on the frounced surface in combination with new embossed patterns on sides and under surfaces, afford rich tactile qualities hitherto unattainable in the air conditioner field.

Harrington & King perforated metals provide the Industrial Designer and other men of ideas unlimited opportunities to offer both functional and aesthetic properties as demanded in products for today's market. Contact H & K for your perforating requirements.

*Product Development by William M. Schmidt Associates



A few of the thousands of H & K perforated patterns. Illustrations are reduced in size.

Fill in and mail coupon to nearest H & K office.

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Harrington & King
PERFORATING CO. INC.

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5671 Fillmore Street
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Please send me—

☐ GENERAL CATALOG NO. 62
☐ STOCK LIST of Perforated Steel Sheets

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TITLE________________
COMPANY________________
STREET________________
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For more information, Circle No. 487

News OF INDUSTRY

Companies

Pencoyd Steel & Forge Corp. has purchased the **Fairmount Steel Corp.** of Phila.

Resistoflex Corp. has doubled production facilities at its plant in Roseland, N. J.

Bendix Aviation Corp. and **Sheffield Corp.** have combined. Sheffield will retain its corporate title as a wholly owned subsidiary.

Brown Fintube Co. has announced that its Fired Heater Div. will be incorporated within a newly formed subsidiary, **Brown Thermal Development Co.**

Borden Co.'s Chemical Div. has established a Forest Products Research Group in Philadelphia for the development of resin and polymer products.

Kelsey-Hayes Co. will erect an 80,000-sq ft building near Springfield, Ohio, for expansion of its Speco Aviation Div.

Robertshaw-Fulton Controls Co.'s Bridgeport Thermostat Div. has opened a new plant at Milford, Conn., which more than doubles the size and output of the old plant. In Philadelphia, the company will consolidate the newly acquired Beta Corp. with its Fielder Instrument Div.

Reactive Metals, Inc., a new firm engaged in melting zirconium and its alloys, is jointly owned by Mallory-Sharon Titanium Corp. and National Distillers Products Corp.

Rust-Oleum Corp. has completed a $500,000 plant addition at Evanston, Ill., that doubles previous output.

Hubbard and Co. has acquired all outstanding stock of **Illinois Gear & Machine Co.**; it is also adding a new plant to its South Works.

Sharon Steel Corp., Brainard Div., is opening a new Product Research Development Laboratory for tool and product development and to increase engineering services.

Daco Machine & Tool Co. has changed its name to **Daco Instrument Co.**

Molded Fiber Glass Companies has

For Compression Molding

of Thermosetting Materials

come to K & J

K & J has always specialized in the compression molding of those materials which maintain their stability, under heat, after molding. But materials vary in their properties — and it is in the selection of the proper molding compounds for your job that K & J plastics engineers can be most helpful. Send for our brochure, "A Service to Users of Compression Molding."

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Phone 1-3170-J2

Wm. T. Wyler
Box 126, Stratford, Conn.
Phone Bridgeport 7-4293

For more Information, Circle No. 411

only the HIGHEST QUALITY is good enough . . .

DEGREES
0
40
80
140
180
220
FOXBORO

6" Concentric Temperature Indicator (Dial Thermometer) by The Foxboro Company

STAINLESS STEEL CAPILLARY, MECHANICAL, HYPODERMIC AND AIRCRAFT TUBING
(.008" to 1.000" O.D.)

NICKEL AND NICKEL ALLOY TUBING
(up to .625" O.D.)

Flanged, Flared, Milled
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Yes, only the highest quality stainless steel capillary tubing is good enough to contribute to the accurate, continuous and superior performance of this Foxboro Dial Thermometer.

Visible, cut away from the sheathing, is BISHOP #316 seamless capillary tubing with a .062" OD and .011" ID. One of many examples where today's Instrument Manufacturers depend on BISHOP quality small diameter tubing.

When you next require quality components of small diameter tubing, turn to BISHOP for the highest quality available.

Research, Engineering and Development services available.

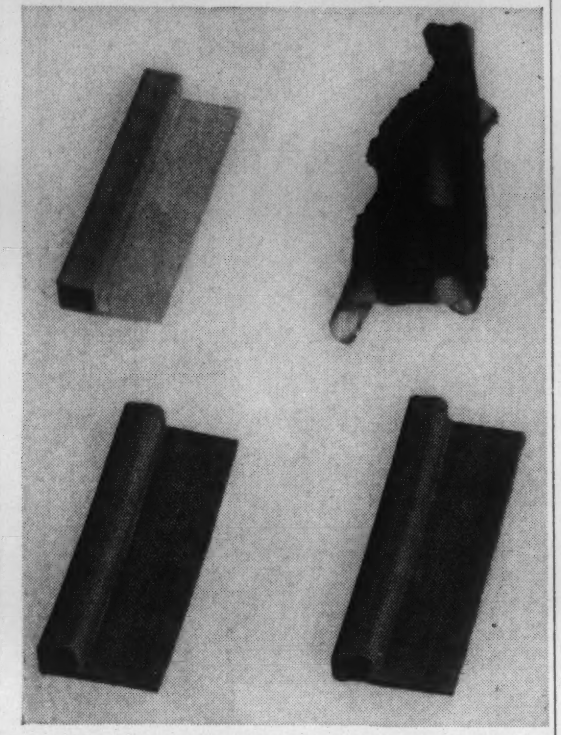
Catalog and Prompt Quotations on Request

STAINLESS STEEL PRODUCTS DIVISION

J. BISHOP & CO. **Platinum Works**
Malvern, Pennsylvania

For more information, turn to Reader Service Card, Circle No. 498

CHR Silicone Rubber NEWS



At left, control samples; at right, seals soaked 16 hours in AN-F-48 (100/130 octane) fuel. Seal made with ordinary silicone rubber (top right) is destroyed. Seal made with new Dow-Corning LS-53 (bottom right) is virtually unaffected and is tough, resilient and operable.

NEW . . . CHR fuel resistant silicone rubber SEALS

Resist jet fuels, hydraulic and synthetic oils, and abrasion in temperatures —85°F to 400°F.

The new Dow-Corning LS-53 is the first rubber to combine fuel resistance with extreme high and low temperature flexibility. This *fluoro-silicone* rubber can be sponged, molded, extruded. It is readily adaptable to seal constructions which provide the most practical and economical use of the rubber.

LS-53 is available *now* and CHR is already designing it into fabric reinforced seal constructions. The outstanding resistance of these seals to one aircraft fuel is illustrated *above. Write or phone* for a CHR data sheet giving full test data. If your need for LS-53 seals is immediate, CHR will expedite seal design coordination and production. Phone or write us. CHR field representatives are available for direct contact.

ALSO AVAILABLE, LS-53 custom molded sheets, extrusions, sponge sheets, sponge extrusions, COATED FABRICS.

CHR THE CONNECTICUT HARD RUBBER CO.
409 East St., New Haven 9, Conn.

For more information, Circle No. 537

completed a $100,000 research and testing laboratory at Ashtabula, Ohio.

Kelsey-Hayes Co. has constructed a new plant near Utica, N. Y. for the Vacuum Metals Div. of its Utica Drop Forge & Tool Div. Kelsey-Hayes will also erect an 80,000-sq-ft building near Springfield, Ohio, for expansion of its Speco Aviation Div.

NRC Vaculite Corp. is the new name of National Research Corp.'s **Foiltone Products, Inc.**

L. A. Young Spring & Wire Corp. has purchased the complete assets of **Flexo Mfg. Co., Inc.,** manufacturers of aluminum honeycombs.

J. I. Case Co. announces consolidation of **American Tractor Corp.** into Case.

Summers Gyroscope Co. is building a new plant, adjacent to the main building, that will more than double its present facilities.

Allmetal Screw Products Co. announces its second Annual Allmetal Stainless Steel Awards competition. Cash awards will total $1500; deadline for entries is June 1.

Jerguson Gage & Valve Co. has moved into its new plant at Burlington, Mass.

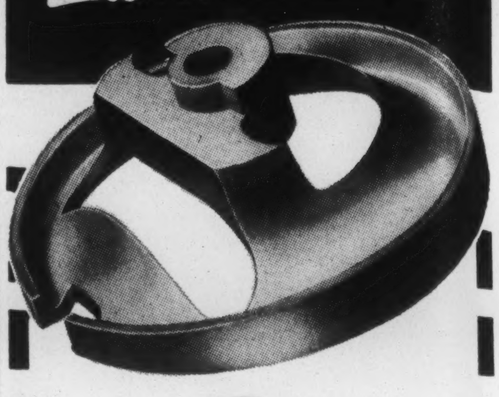
Societies

Federation of Paint and Varnish Production Clubs has named Joseph W. Tomecko, of Canadian Industries, Ltd., president-elect.

Aluminum Assn. elected the following officers at its annual meeting: president, S. D. DenUyl, Bohn Aluminum & Brass Corp., vice presidents: Russel B. Caples, Anaconda Aluminum Co.; W. E. Dunlap, Aluminum Extrusions, Inc.; Frank R. Nichols, Nichols Wire & Aluminum Co. Board members are: honorary chairman, Arthur V. Davis, Aluminum Co. of America; chairman of the board, Everett G. Fahlman, Permold Co. Directors-at-large are: George A. Ginsburg, United Smelting & Aluminum Co., Inc.; David P. Reynolds, Alcoa.

(more news of Societies on p 300)

Cam Milling and Contour Machining *Eliminated!*



This EpCo INVESTMENT CASTING Proves the Point

PART: Cam for Aircraft Instrument

MATERIAL: Stainless Steel, 440

PROBLEM: To reduce time and cost involved in setting up and performing 8 different types of machining operations.

SOLUTION: An EPCO Investment Casting Completely dispensed with

1. Cut-off
2. Turning O.D.
3. Center Hole Drilling
4. Form Turning
5. Form Milling
6. Contour Milling
7. Slot Milling
8. Cam Milling

Leaving only cam polishing, bottom grinding and hole reaming.

CONCLUSION: Intricate Machine Parts by redesigning to EPCO Investment Casting tolerances can be made to give *better* performance at far less cost.

Send us drawings, samples and specification of parts for detailed process analysis and cost quotation without cost or obligation.

ENGINEERED PRECISION CASTING CO.
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MEMBER INVESTMENT CASTING INSTITUTE

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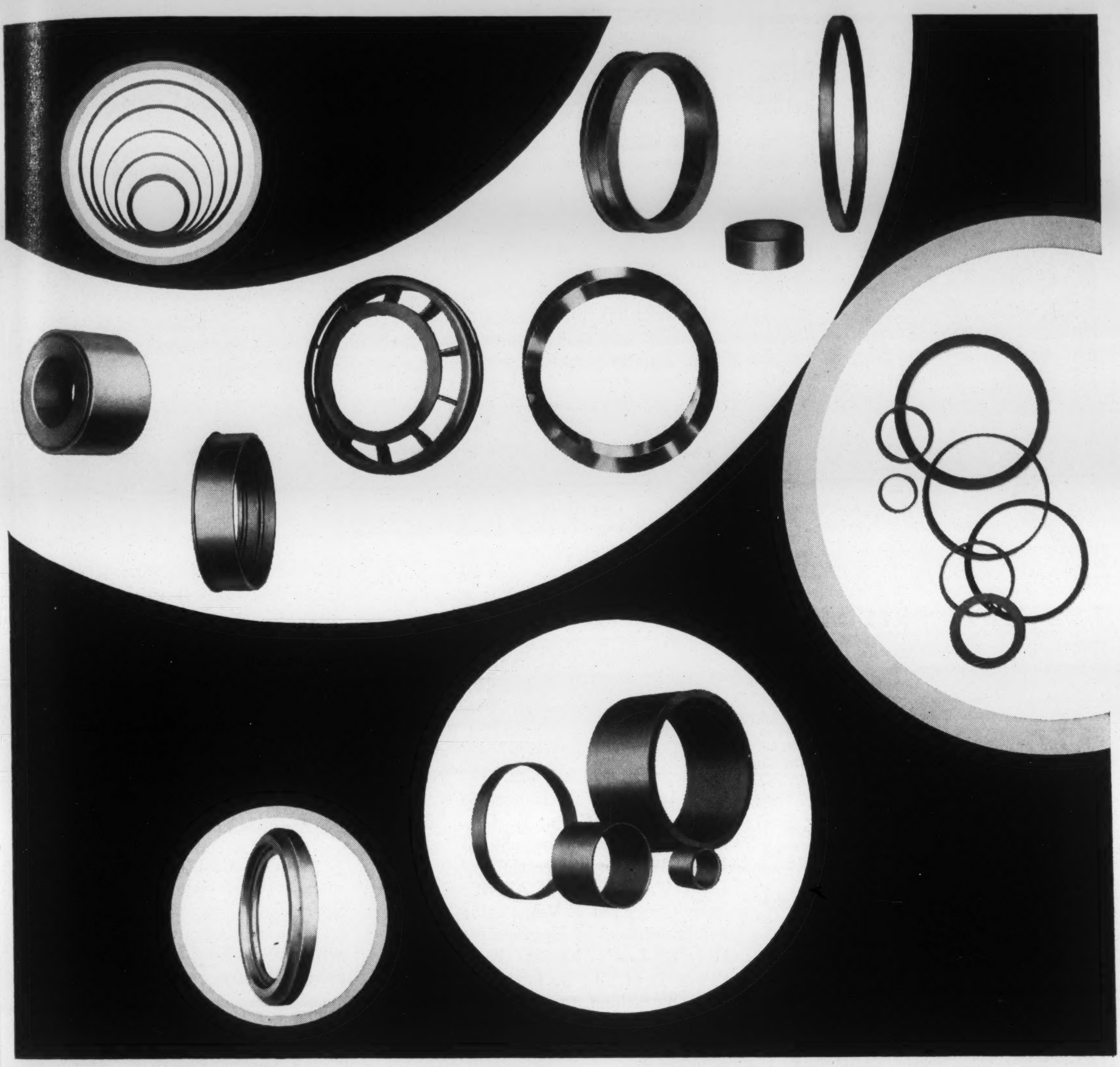

IF THE PROBLEM IS CIRCULAR... BRING IT TO CLEVE-WELD

If you now use circular parts that are cast or forged, or if you are planning a new circular component, consider the Cleve-Weld Process for three reasons:

1. We can cut your waste costs up to 30% over bulky cast or forged parts.
2. We can eliminate excessive machining by designing sections suitable to your needs.
3. We can, consequently, help you speed your over-all production and cut costs further.

Where expensive alloys and "wonder metals" are involved, we may be able to save you enough in waste and machine time to pay for the finished part.

Our proposition is simple. We have 45 years of design, metallurgical and production experience that can probably save you money. To find out, call, or write and send drawings to: Circular Welded Products Department, Cleveland Welding Company, West 117th Street and Berea Road, Cleveland 11, Ohio.

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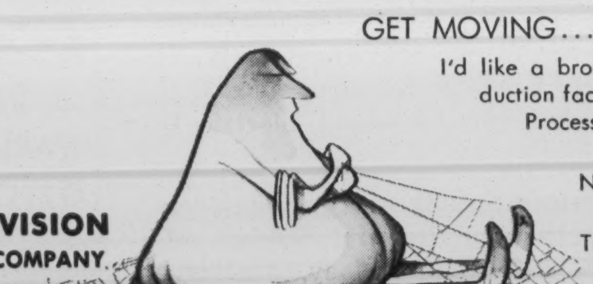
CLEVE-WELD PROCESS
RIMS • RINGS • WELDMENTS

CLEVELAND WELDING DIVISION
AMERICAN MACHINE & FOUNDRY COMPANY
Cleveland 11, Ohio



GET MOVING... MAIL THIS COUPON NOW! MM-704

I'd like a brochure on Cleve-Weld's metallurgical, design and production facilities. Particularly, I'd like to know how the Cleve-Weld Process can cut component costs while improving performance.

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TITLE______________________________

ATTACH TO YOUR COMPANY LETTERHEAD AND MAIL TODAY!

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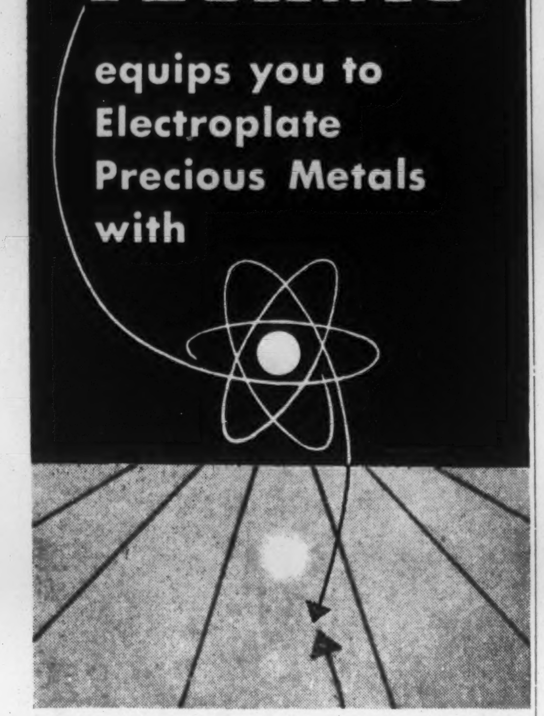
equips you to Electroplate Precious Metals with



SCIENTIFIC PRECISION

Technic, Inc. equips you with controlled apparatus and electroplating solutions to maintain exacting standards and close tolerances. Typical benefits are the spectacular economics Technic effects in handling gold — where often electroplaters lose up to $60,000 or more of every $100,000 worth through outmoded equipment, inefficient methods and solutions.

TECHNIC ENGINEERING

Technic engineers design and install your equipment — and stand by until performance is assured. *No installation is complete without this follow-through.*

TECHNIC PRODUCTS

Technic Potassium Gold Cyanides, Concentrated Aqueous & Dry • Technic Electroplating Solutions: Rhodium, Platinum & Palladium • Technic Immersion Tin • Technic Protectox Anti-Tarnish • Technic Flame Flux

TECHNIC EQUIPMENT

Technic Electroplating Systems • Technic Germanium Diode Rectifiers • Technic Turbomatic Agitators • Technic Electroplating Barrel Unit • Automatic Techni Timers

TECHNIC BIBLIOGRAPHY

Technic publications, authoritative in our field: "Electroplated Gold"; "Precious Metal Electroplating Data: Gold, Rhodium, Palladium, Platinum, Silver, Nickel"; "Electroplated Platinum"; "Electroplated Palladium"; "Electroplated Rhodium"; "Analysis of Gold & Gold Alloy Solutions".

Consult us without obligation, whether in respect to a new installation and electroplating solutions, or an existing system now in use. Write for Technic publications in your field of interest.

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TECHNIC INC. PRODUCTS OF RESEARCH

THE LARGEST ENTERPRISE OF ITS KIND IN THE WORLD

For more information, Circle No. 435

News OF INDUSTRY

Institute of the Aeronautical Sciences, Council has elected the following 1957 Area Counselors: Joseph J. Jerger, consulting engineer; Earle Stewart, Vertol Aircraft Corp.; Smith J. DeFrance, Ames Aeronautical Laboratory, NACA; George R. Mellinger, North American Aviation, Inc.; John D. Akerman, Institute of Technology, Univ. of Minnesota; Maurice J. Zucrow, Purdue University.

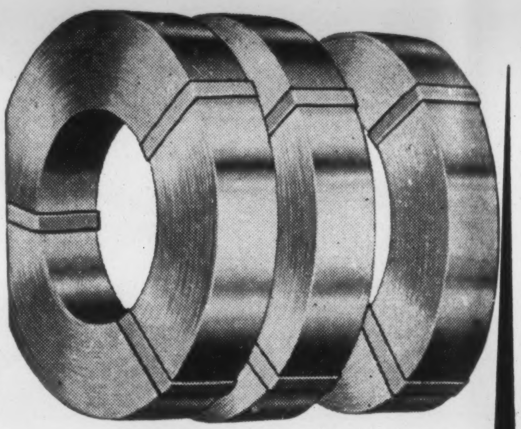
American Institute of Electrical Engineers has bestowed the grade of Fellow on 16 electrical engineers for notable contributions in their fields and to the profession. The new Fellows are: Victor H. Braunig, City Public Service Board, San Antonio, Texas; Volney J. Cissna, Tennessee Valley Authority; Anatole R. Gruehr, Polytechnic Institute; Thomas J. Higgins, Univ. of Wisconsin; Russell M. Kerchner Kansas State College; Clarence H. Linder, General Electric Co.; Lawrence J. Lunas, Westinghouse Electric Corp.; Earl F. Mekelburg, Square D Company; John A. Potts, Wisconsin Electric Power Co.; Leon T. Rosenberg Allis-Chalmers Mfg. Co.; Fred J. Van Zeeland, Milwaukee School of Engineering; S. B. Morris, Los Angeles Water and Power Dept.; L. R. Patterson, Electric Operations Public Service Co.; A. H. Phillips, Gilbert Associates, Inc.; H. I. Romnes, American Telephone & Telegraph Co.; Victor Siegfried, Ansonia Wire & Cable Co.

AIEE has also announced its 1957-58 slate of officers: president, Walter J. Barrett, N. J. Bell Telephone Co.; treasurer, L. F. Hickernell, Anaconda Wire & Cable Co. The five vice presidents are: Benjamin R. Teare, Jr., Carnegie Institute of Technology; Robert W. Oetinger, Duke Power Co.; Albert G. Johnson, Omaha Public Power District; Orien A. Gustafson, General Electric Co. San Francisco; Geordon F. Tracy, University of Toronto. Directors are: E. W. Morris, Westinghouse Electric Corp., Los Angeles; W. R. Clark, Leeds & Northrup Co.; J. C. Strasbourger, Cleveland Electric Illuminating Co.

American Society of Tool Engineers has chartered its first foreign offshore chapter in Sydney, Australia.

(news of Meetings on p 302)

Alloy Strip in Precision Sizes meets New Design Needs...



From 0.0005 in. to 0.040 in. thick and 0.090 to 6 in. wide, these alloys are available as special-tolerance strip:

- Beryllium Copper
- Phosphor Bronze
- Nickel Silver
- Brass
- Chromium Copper
- Stainless 17-7PH
- Invar
- Magnetic: High Nickel

Some immediately available. Others rolled to order in 2 to 21 days. Can be supplied in coils or straight lengths with slit or filed edges—also cadmium plated.

Write for Bulletin 7 TODAY.

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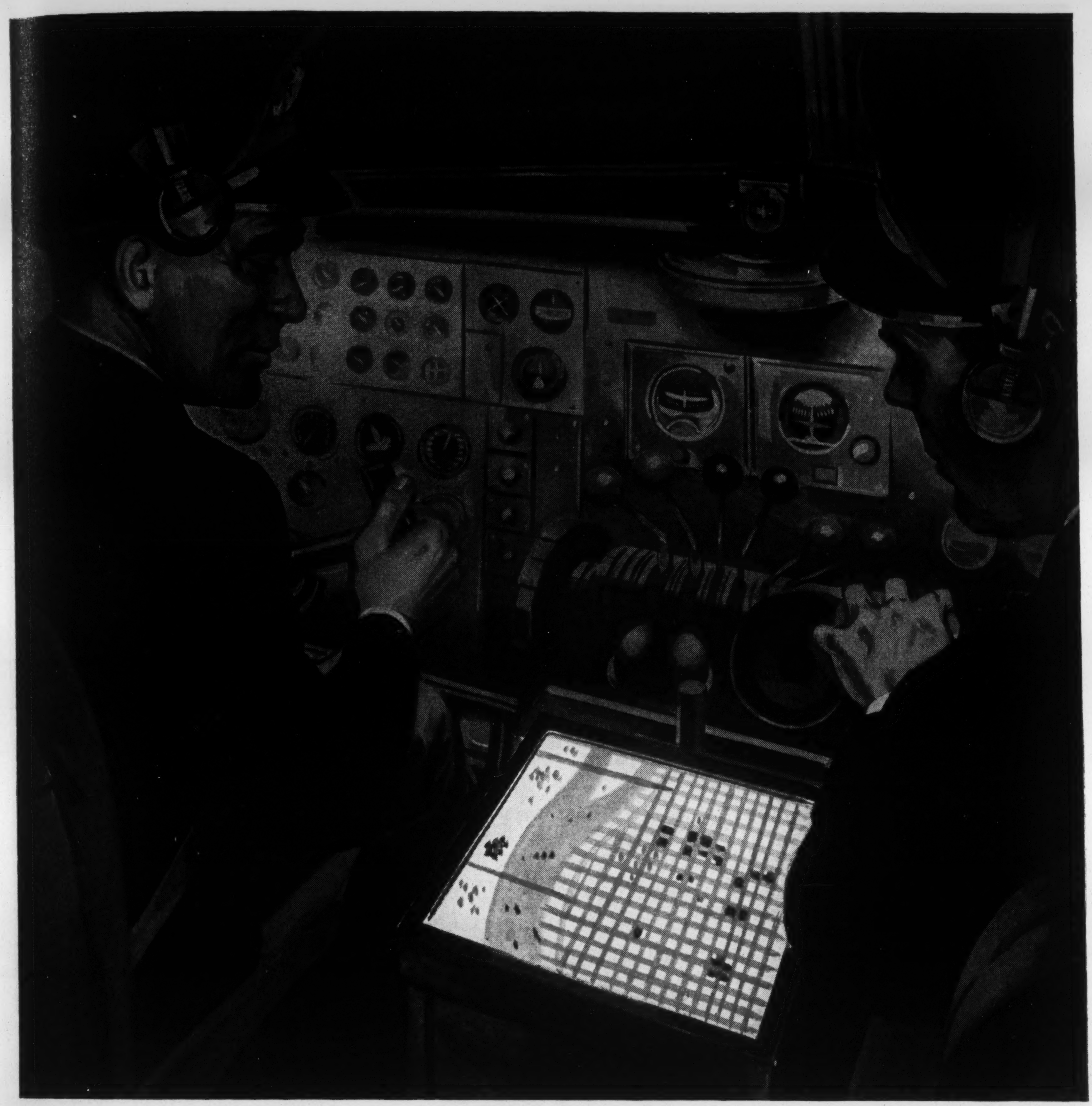
Cleveland — *L. D. ALSPACH*
Philadelphia — *J. A. RHODES*, *Bala-Cynwyd, Pa.*
St. Louis — *J. A. CROWE*
Houston — *RANDOLPH SALES CO.*
Los Angeles — *KRUSEN WIRE & STEEL CO.*

WAREHOUSES

NEW YORK — *BERYLLIUM COPPER SUPPLY CO.*, *Little Falls, New Jersey*
Chicago — *PRECISION STEEL WAREHOUSE INC.*
Los Angeles — *KRUSEN WIRE & STEEL CO.*

For more information, Circle No. 432



Next—pilots will watch their own landings on TV!

Up from pitch-dark airfields come light signals invisible to the human eye . . . A new electronic "cat eye" in the cockpit amplifies these signals to produce daylight pictures of the ground on the pilot's television screen.

Thus, in blackout or encased in radiation-proof cockpits, tomorrow's pilots will guide their planes in to safe landings by this latest triumph of electronics.

Like the electronic age itself, the fabulous "cat eye" depends for its operation on the very best of electrical insulations—the kind CDF has been manufacturing for over sixty years.

FOR SPECIFIC INFORMATION on CDF products, see Sweet's, Electronics Buyers' Guide, and other directories. Then send us your print or your problem, and we'll return free samples and technical literature.

CDF MAKES Dilecto Laminated Plastics • Celoron Molded Plastics • Micabond Mica Products • Diamond Vulcanized Fibre • Flexible Tapes of Teflon*, Silicone, and Micabond • Resin-Impregnated Spiral Tubing • *Complete Fabrication Facilities.*

*duPont trademark for its tetrafluoroethylene resin

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE BUDD COMPANY • NEWARK 25, DELAWARE

For more information, turn to Reader Service Card, Circle No. 496

For more information, turn to Reader Service Card, Circle No. 559

Roto-Finish

processes give you
- tremendous savings
- high production
- uniformity of finish

Savings on deburring, descaling, grinding, polishing, coloring and surface improvement by Roto-Finish barrel finishing processes are tremendous. Expensive hand finishing can be eliminated.

Results Guaranteed! Send samples of finished and unfinished parts to Roto-Finish. Roto-Finish Sample Processing Laboratories will prove to you — before you buy — that Roto-Finishing will give you the results you want. Furthermore, Roto-Finish guarantees to produce the same results in your plant that are achieved in sample processing.

Let Us Help You with Your Problems

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WHAT IS "FERNLOCK"?

"Fernlock" is a dendritic copper powder offering a hard to get combination of properties not found in either flake or granular copper powders. Check these special features. Fernlock may be just the material you need for that special problem.

1. High Purity (99.50% Min.)
2. Low Density (1.1 gr/cc Max.)
3. Fine Mesh Size (75% through 325)
4. Dendritic Particle Structure (See Photo—250 diameters)
5. Very High Green Strength (The particles interlock under pressure)

MALONE METAL POWDERS, INC.

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New York 36, N. Y.
Phone: WIsconsin 7-7250

For more information, turn to Reader Service Card, Circle No. 437

News OF INDUSTRY

Meetings

LEAD INDUSTRIES ASSN. annual meeting. Chicago. Apr 24-25.

AMERICAN ZINC INSTITUTE, INC., annual meeting. Chicago. April 25-26.

METAL POWDER ASSN. annual meeting and Metal Powder Show. Chicago. Apr 30-May 1.

ENGINEERED CASTINGS SHOW, American Foundrymen's Society. Cincinnati. May 6-10.

AMERICAN FOUNDRYMEN'S SOCIETY, annual convention. Cincinnati. May 6-10.

COPPER & BRASS RESEARCH ASSN. annual meeting. Hot Springs, Va. May 12-15.

ELECTROCHEMICAL SOCIETY, INC., spring meeting. Washington, D. C. May 12-16.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, design engineering conference. New York. May 20-22.

DESIGN ENGINEERING SHOW. New York Coliseum, New York. May 20-23.

AMERICAN IRON AND STEEL INSTITUTE, 65th general meeting of members. New York. May 22-23.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, INSTITUTE OF METALS DIV., annual conference. Boston. May 17-18.

SOCIETY OF AUTOMOTIVE ENGINEERS, summer meeting. Atlantic City. June 2-7.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, semiannual meeting. San Francisco. June 9-13.

MAGNESIUM ASSN., annual meeting. Hot Springs, Va. June 10-11.

MALLEABLE FOUNDERS' SOCIETY, annual meeting. Colorado Springs. June 13-14.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting. Atlantic City. June 16-21.

AMERICAN ELECTROPLATERS' SOCIETY, annual convention. Montreal. June 17-20.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION, annual meeting, Cornell Univ., Ithaca, N. Y. June 17-21.

ALLOY CASTING INSTITUTE, annual meeting. Hot Springs, Va. June 23-25.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, summer general meeting. Montreal. June 24-28.

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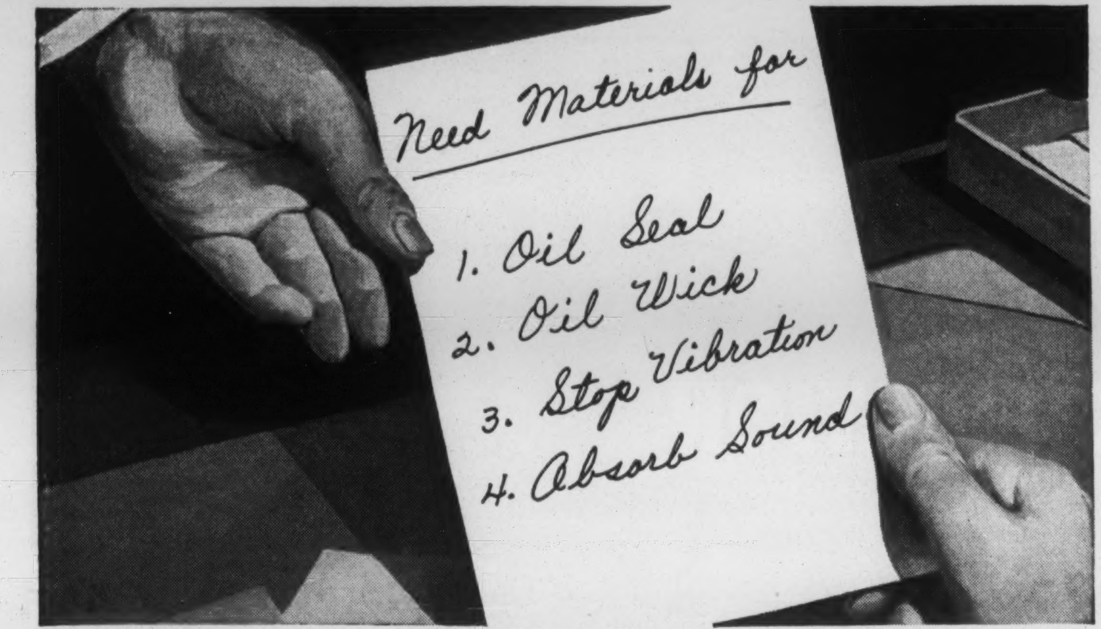

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BOOKS & REPORTS

Books

Relaxation Properties of Steels and Super-Strength Alloys at Elevated Temperatures. *Prepared by James W. Freeman and Howard R. Voorhees. ASTM Special Technical Publication No. 187, American Society for Testing Materials, Philadelphia. 1956. Paper, 8½ by 11 in., 102 pp. Price $4.00*

Summarizes a study of relaxation strengths for low alloyed molybdenum, chromium and vanadium bearing steels, carbon steel wires, cast iron, nickel-base alloys and iron-base alloys. Residual stresses for relaxation to 100, 500, 1000 and 10,000 hr are the main measure of relaxation strength. Elevated temperatures used in the evaluation range from 750 to 1100 F, with data at 1200 to 1500 F for super-strength alloys. In each case, the relaxation strength is a function of the initial stress as well as chemical composition and heat treatment. A graph compares relaxation strengths of the various alloys.

The Final Forming and Shaping of Wrought Nonferrous Metals. *Institute of Metals, London, England. 1956. Cloth, 8¾ by 11 in., 128 pp. Price $3.50*

The illustrated papers given in this book discuss: 1) machining properties of nonferrous metals, 2) deep drawing and spinning of sheet metal, with particular reference to nonferrous materials, 3) rubber pressing of aluminum and magnesium alloys, 4) research into some metal forming and shaping operations, 5) cold roll forming and manipulation of light gage sections, 6) stretch forming of nonferrous metals, 7) bending and allied forming operations, and 8) hot forming of magnesium alloys.

Nickel Handbook and Commercial Outlook for 1957. *Herman B. Director Associates, 1511 K St., NW, Wash. 5, D.C. 1956. Paper, 8½ by 11 in., 70 pp. Price $10.*

Designed as a handbook for purchasing agents and management, as well as sales and marketing executives, this book looks into the supply and demand status of nickel in 1957

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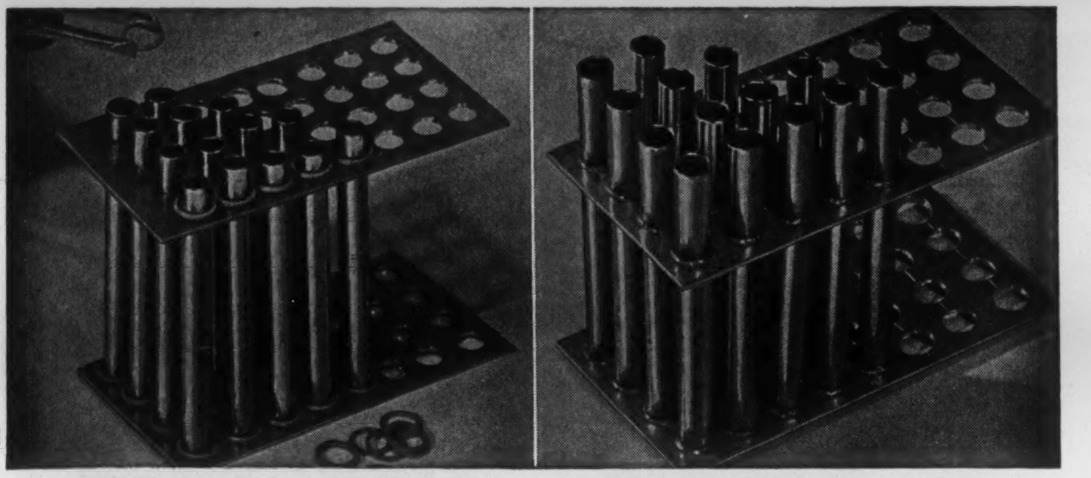

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BOOKS & REPORTS

and gives valuable information concerning its production and consumption. It contains an index of both primary and secondary nickel suppliers and gives prices and government activities in nickel. It also lists nickel plating supply houses and nickel jobbers. In addition, a description and reproduction of government priorities and export regulations are given.

Mr. Director compiles MATERIALS & METHODS' monthly forecast on price and supply trends in engineering materials and conducts his own market research firm in Washington.

Engineering Uses of Rubber. *Edited by A. T. McPherson and Alexander Klemin. Reinhold Publishing Corp., New York 22, N. Y. 1956. Cloth, 6¼ by 9¼ in., 490 pp. Price $12.50.*

Designed for everyday use by engineers both in and out of the rubber industry, this book, written by 18 well known rubber technologists, reveals why and how rubber is used. It gives information on the manufacture of rubber products; the properties, behavior and industrial applications of rubber; and information on how to specify and purchase standard and special rubber products.

Uses of natural and synthetic rubber in such products as tires, electrical insulation, tank linings, conveyor belts, automobile suspension springs and aircraft fuel cells are discussed from the standpoint of composition, and mechanical, thermal and chemical properties. A brief explanation of the mechanical behavior of rubber is given in terms of molecular structure.

Reports

High temperature alloy THE DEVELOPMENT OF A FORGEABLE HIGH STRENGTH, HIGH TEMPERATURE, CHROMIUM-RICH, CHROMIUM-IRON ALLOY, PART 2. *D. P. Moon, H. A. Blank and A. M. Hall, Battelle Memorial Institute. Oct 1954. 26 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. 75¢ (PB 121111)*

Describes production of experimental chromium-rich, chromium iron alloys by induction melting. The alloys were cast into molds and fabricated by various hot working methods. Forged bars showed good thermal shock properties up to 2000 F.

(more Reports on p 308)

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BOOKS & REPORTS

Damping properties THE EFFECT OF STATIC MEAN STRESS ON THE DAMPING PROPERTIES OF MATERIALS. *N. L. Person and B. J. Lazan, Univ. of Minnesota. July 1956. 34 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1 (PB 121522)*

Damping properties of materials were investigated through the use of newly developed vibration decay equipment which determined the effect of static mean stress on the damping associated with a given alternating stress. A type 403 stainless steel showed a 90% decrease in damping energy when superimposed static mean stress was increased from 0 to 40,000 psi.

Titanium carbide IRON BONDED TITANIUM CARBIDE. *R. E. Wilson, New York State College of Ceramics. Dec 1953. 39 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1 (PB 121-323)*

Physical properties of iron bonded titanium carbide were found to be inferior to those of nickel bonded titanium carbide for use in aircraft power plants. However, effective techniques were developed for pressing iron bonded titanium carbide into various shapes.

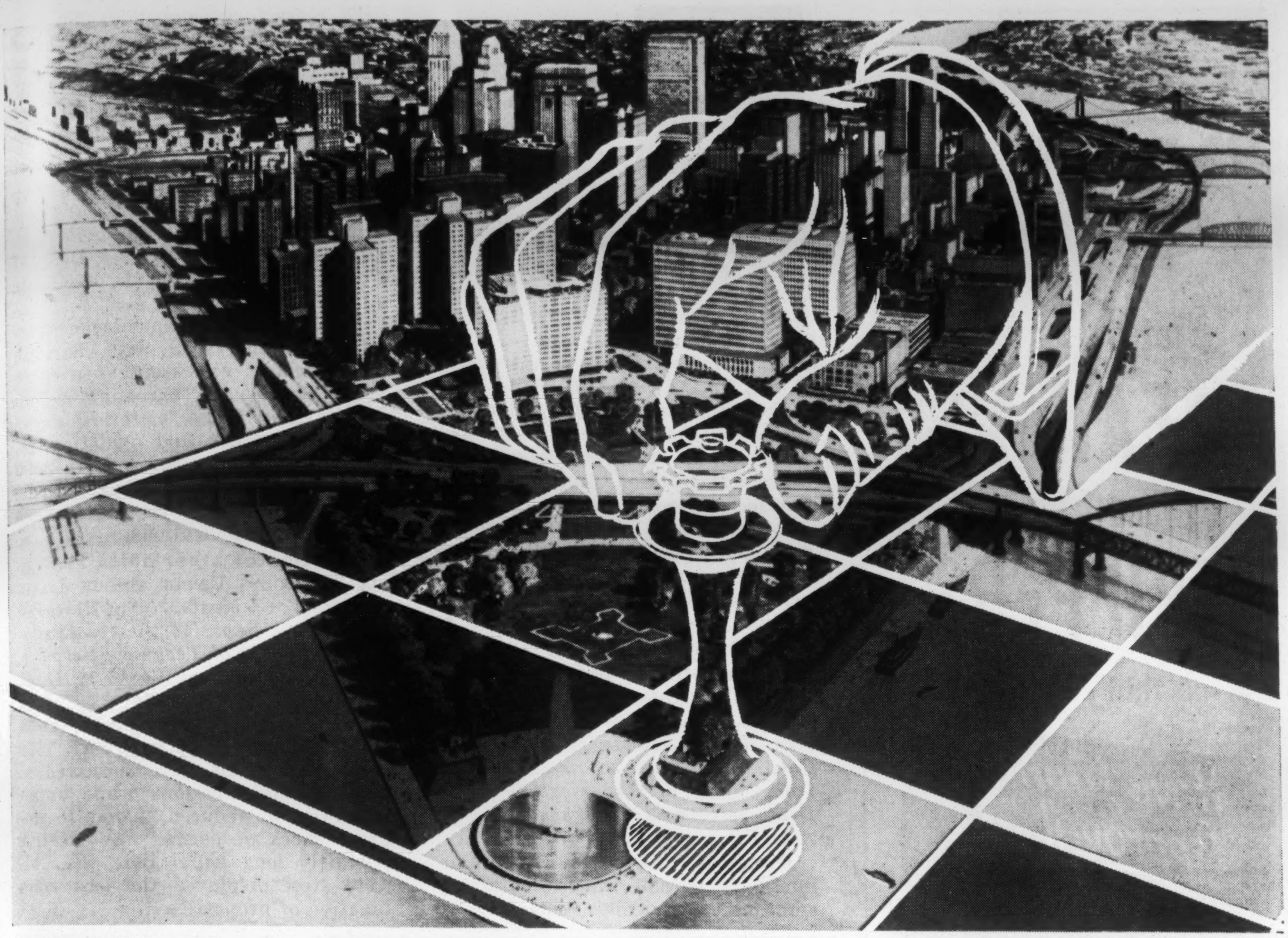
Fluorocarbon elastomers SYNTHETIC RUBBERS FROM CARBON-FLUORINE COMPOUNDS. *Frank A. Bovey, Minnesota Mining and Mfg. Co. Apr 1956. 67 pp.. illus. Available from Office of Technical Services. Dept. of Commerce. Wash. 25, D.C. $1.75 (PB 121351)*

Evaluation of fluorine-containing elastomers with wide temperature ranges and resistance to solvents, hydraulic fluids, lubricants and other liquids. Includes studies of homopolymers and copolymers of fluorinated dienes and copolymers of 1,1,2-trifluorobutadiene with 1,1-dihydroperfluorobutyl acrylate (FBA).

Nickel consumption A BASIS FOR FORECASTING NICKEL DEMANDS IN THE UNITED STATES. *Available from Henry D. Lytton, 1326 27th St.. NW, Washington 7, D.C. $7.50. (Library of Congress Cat. No. 56-39509)*

A survey of 45 years of nickel consumption and derivation of a demand formula, with nickel forecasts from 1956 to 1965. Gives a brief supply outlook and indicates trends of competing ferroalloys and nonferrous metals. Also compares the marketing of nickel and aluminum.

(more Reports on p 310)



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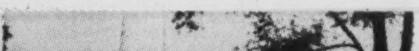

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BOOKS & REPORTS

Correlating creep data CORRELATIONS OF HIGH TEMPERATURE CREEP DATA. *O. D. Sherby and J. E. Dorn, Univ. of California, June 1955. 37 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1 (PB 121287)*

Experiments on aluminum and nickel reveal that creep at high temperatures is controlled by a single thermal activation process. Simple parameters to correlate creep strain, secondary creep and stress rupture were successfully applied to very high temperature data on iron, copper, molybdenum, beryllium, commercial steels, cast irons and complex high temperature alloys.

Aluminum-base powder alloys POWDER FABRICATION OF ALUMINUM ALLOYS. *J. B. Hess and R. S. Mateer, Kaiser Aluminum & Chemical Corp. Sept 1955. 29 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. 75¢ (PB 121138)*

Discusses preparation of aluminum-base powder alloys containing additions of various intermetallic and refractory compounds not usually alloyable with aluminum. These compounds improved Young's modulus but tensile properties were mediocre because the additions were dispersed in a matrix of unalloyed aluminum.

Cemented borides CEMENTED BORIDES. *American Electro Metal Corp. July '55. 140 pp, illus. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $3.50 (PB 121346)*

Summarizes experimentation during 1954 and 1955 with Barolite IV, a cermet consisting of a chromium boride and chromium-molybdenum alloy. The material shows good heat, shock and oxidation resistance at temperatures above 2000 F. However, it has low impact resistance which hinders its use in high temperature applications.

Properties of steel bolts PROPERTIES OF BOLTS UNDER SHOCK LOADING. *E. W. Clements, Naval Research Laboratory. Sept. '56. 40 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $1.25 (PB 121372)*

Bolts prepared from SAE 4140, SAE 1020 hot rolled, and SAE 1020 cold rolled steels were subjected to various shock motions while under load. Use of reduced shanks to improve shock properties was effective in fairly long bolts. Bolts of SAE 4140 steel displayed the best combination of properties.

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THE LAST WORD

by **H. R. Clauser**, *Editor*

Last Word on the Right Word

The Last Word is now on TV. I must hasten to say that it is not *me (I)* and this column that *are (is)* the program. It is a program *that (which)* deals with the proper and improper use of the English language and is conducted by the well known Dr. Bergen Evans of Northwestern University. Every Sunday afternoon he and a small panel of well known personalities get into some lively discussions and thereby demonstrate that dealing with English usage can be entertaining as well as informative.

I recommend the program to all engineers, because it very effectively puts grammar in its proper place. Grammar is a tool or a means to an end, not an end in itself. Most of those who are forever criticizing the engineer for his poor writing are really criticizing his failure to follow the textbook rules on such matters as split infinitives, prepositions at ends of sentences, and the use of the words set in italics in the above paragraph. Although the rules should not be ignored, it is important to realize that good writing is not simply a matter of closely following all the rules. Above all, clear writing is based on clear thinking. Careful adherence to all the grammatical rules in the book will never transform inaccurate, sloppy thinking into clear, simple, easily understandable writing.

Church Has a Place for Metallurgists

One of the constantly recurring problems for local sections of technical societies is where to hold their monthly meetings. Most groups like to have dinner meetings, but it is difficult these days to find a place that serves a good meal at a reasonable price, and is also satisfactory for the technical session.

The Columbus Chapter of the American Society for Metals has found a unique solution to this problem; it meets in the recreation hall of a church and has been doing so for the past five years. The hall is spacious and comfortable as I found when I spoke there last month. And the ladies auxiliary of the church prepares and serves a delicious home-cooked dinner for two dollars.

What more could one want? Oh yes, cocktails. Well, the few who want or need a drink (such as the speaker) congregate at a nearby bar and satisfy their thirst before going on to the meeting.

Chestless Plastics Drawers

The first MATERIALS & METHODS Awards Competition is over, the judging is completed, and the winners will be announced in next month's issue. The response was way above our expectations and the quality of many of the entries was excellent.

Although the competition was concerned with selection and use of materials, a number of the products were particularly interesting in themselves. One of the most interesting is a set of dice mounted on a top. When the top is spun the dice perform somewhat like a gyroscope. The inventor hopes his device will replace the old manual method of shaking the dice and thus make for a more honest game.

Another of the products should prove a boon to all gas station attendants. It is an automobile battery cap designed to show the level of the electrolyte without the need for removing the cap.

Perhaps the most intriguing of the entries was the one on chestless plastics drawers. No, they are not, as you might think, underwear without tops. The chestless plastics drawer is actually a new concept of furniture design which makes possible the construction of chests of drawers without any enclosing cabinet work.